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ABSTRACT

In October 1988, the Workplace Hazardous Materials Information System (WHMIS) became law in Canada and was applied to school classrooms and laboratories. Educators expressed concerns that difficulties in implementation would negatively affect student laboratory activity. In 1994, a survey of 219 randomly selected Manitoba junior and senior high school science teachers (128 rural and 91 urban) examined issues related to implementation and effects of WHMIS regulations. Results show that while WHMIS knowledge and implementation were generally low, rural teachers scored significantly lower than urban teachers. Both rural and urban teachers scored higher on items that were part of their safety routines before WHMIS regulations. Urban and rural teachers reported few accidents, and accidents were not a result of noncompliance with WHMIS. WHMIS inspections were related positively to higher knowledge and implementation categories. Higher WHMIS knowledge and implementation scores were associated with the following teacher characteristics: more experience in subjects and grade levels currently assigned, teaching grades 11-12, more university science courses, more science methods and curriculum courses, and access to a laboratory assistant. Compared to rural teachers, urban teachers had a significant advantage in most of these areas. High percentages of both rural and urban teachers met or exceeded the number of science activities recommended by grade 11-12 provincial guides. The effect of WHMIS implementation on student laboratory activity was inconclusive. Contains 33 references. (Author/SV)

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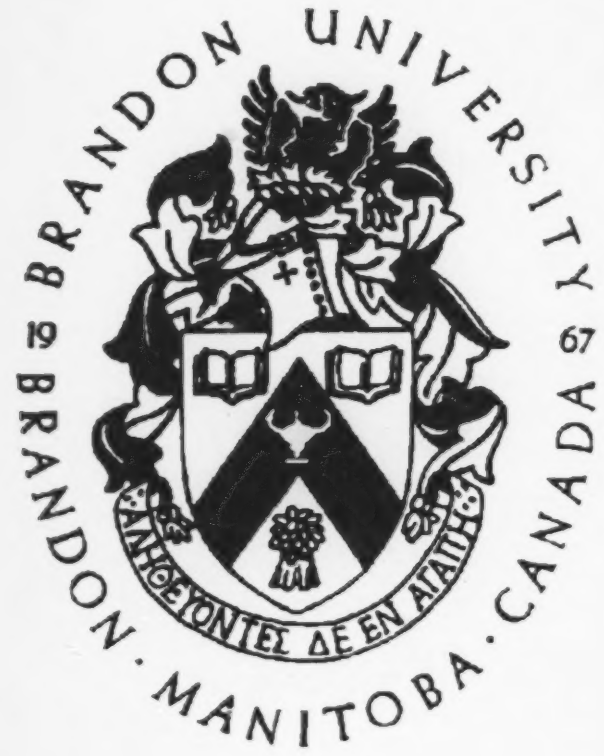

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A Rural-Urban Comparison Of The Knowledge And Implementation Of WHMIS Safety Regulations By Manitoba Science Teachers

by

Barbara Ellen Rice

The Rural Development Institute
Brandon University

1996

Rural Education Research Series No. 5

This research was sponsored by a special grant from Manitoba Education and Training to the Rural Development Institute to sponsor graduate research in rural Education. This report is derived from a Project presented by the author to the Faculty of Education at Brandon University in partial fulfillment of the requirements for the degree of Master of Education.

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PREFACE

In 1991, Manitoba Education and Training, Manitoba Rural Development and the Rural Development Institute at Brandon University announced the Graduate Research in Rural Education program. This cooperative program was designed to 1) provide a framework for focusing on educational issues related to rural Manitoba, 2) provide assistance to graduate students who intend to study rural education, and 3) provide the Department of Education and Training with information for addressing education issues within the broader context of rural development.

To ensure that information is distributed widely, RDI retains the option of publishing results after theses and projects have been approved. In this manner, rural education is placed on the local and provincial agendas for debate, and citizens have access to information which may affect programs for their children. Development of the human resources of rural Manitoba remains the most significant endeavour in rural development.

The Rural Development Institute is pleased to announce the fifth in our series of publications on Rural Education Research. Joan Rollheiser, Administrative Assistant at RDI, prepared the document for publication. We thank Barbara Rice for her efforts on the project. Dr. John Didyk of Manitoba Education and Training, and Bob Grodzik of Manitoba Rural Development assist in the Rural Education Research Program.

Dr. R. C. Rounds, Series Editor
Director, RDI

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Thanks are also due to Dr. Nina Caldwell, Dr. Barbara Gfellner and all of the Brandon science teachers who generously gave their time in the evaluation and testing of the survey questionnaire. Dr. Fred Renihan, Dean of Education, was instrumental in obtaining the list of Manitoba science teachers and Dr. Jeff G. Williams, Professor of Mathematics, helped clarify the statistical implications of the study.

The study would have been impossible without the co-operation of all of the Manitoba teachers who kindly took the time to respond to the questionnaire and I am extremely grateful to each of them.

Finally, I wish to thank Dr. Richard Rounds and the Rural Development Institute, whose generous funding enabled the research to be done on a large enough scale to produce meaningful results.

ABSTRACT

In October, 1988, the Workplace Hazardous Materials Information System (WHMIS) became law and was applied to school classrooms and laboratories. Concerns were expressed by educators that difficulties in required inventorying, labelling and obtaining material safety data sheets would have a negative effect upon student laboratory activity.

In this study, an investigation of issues related to implementation of the WHMIS regulations is made through the analysis of questionnaire responses of 219 randomly selected Manitoba junior and senior high school science teachers (128 rural and 91 urban). The teachers are questioned on 1) knowledge and implementation of WHMIS regulations, 2) teacher and school characteristics which might relate to successful implementation, 3) the amount of student laboratory activity, 4) changes in that activity since the enactment of WHMIS, and 5) their laboratory accident record.

Results show that while WHMIS knowledge and implementation is generally low, rural teachers score significantly lower than urban teachers. Both rural and urban teachers score higher on items that were part of their safety routines before the WHMIS regulations came into effect. Urban and rural teachers report few accidents and the accidents are not a result of non-compliance with WHMIS. WHMIS inspections are related positively to higher knowledge and implementation categories.

Higher WHMIS knowledge and implementation scores are associated with the following teacher characteristics: 1) more experience in subjects and grades currently assigned, 2) teaching grades 11-12, 3) more university science courses, 4) more science methods and curriculum courses and 5) access to a laboratory assistant.

Urban teachers have a significant advantage in terms of experience in current assignments, professional courses taken and access to laboratory assistants. Because implementation of the regulations currently is mandatory, variables that are positively related to implementation deserve further study.

High percentages of both rural and urban teachers meet or exceed the number of activities recommended by grade 11 - 12 provincial curriculum guides. There is no significant rural-urban difference in number of activities.

Teachers who report WHMIS-related changes in laboratory activities have higher WHMIS scores and more frequently report an overall decrease in student laboratory activities. There is no relationship between WHMIS categories and the amount of student laboratory activity, however, and the effect of WHMIS implementation on student laboratory activity is inconclusive. Suggestions are made for further research.

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INTRODUCTION

The Workplace Hazardous Materials Information System (WHMIS)

Increasing numbers of industrial accidents and research indicating the possible long-term health effects of exposure to hazardous or toxic chemicals raise concerns about the handling and transportation of hazardous materials. The governments of various countries, including Canada and the United States, have introduced laws governing the transportation, storage and disposal of chemicals. One important aspect of this legislation is the workers' rights to know about any hazards they might encounter on the job. This legislation involves three major areas: 1) Labelling, which allowed workers to instantly recognize all hazardous products with which they came into contact, 2) Material Safety Data Sheets, which provide more detailed information about all labelled materials regarding the type of hazard posed, correct handling techniques and first aid instructions should an accident occur, and 3) workers' training in recognition of labels, use of data sheets and workplace practices that would minimize danger.

In Canada, joint federal and provincial workplace safety laws and regulations, including the Workplace Hazardous Materials Information System (WHMIS) came into effect in October, 1988. According to the wording of the regulations, schools are regarded as workplaces and teachers placed in the same position as employers in terms of responsibilities for their students' safety (Workplace Safety and Health Act, Chapter W210, 1987, p.3). Employers ignoring the new legislation are subject to penalties. Thus, for science teachers, curriculum changes are required by a source remote from the classroom. There was neither demand for such changes from the teachers themselves nor were they involved in formulating the regulations.

There are three main areas of the WHMIS regulations to be implemented by science teachers. First, instructors are to inventory all hazardous substances in the school and ensure correct labelling of every container. All materials stored in bulk are to carry bilingual, hash-bordered, supplier labels that list the substance name, chemical composition, particular dangers and precautions to be taken. The label also advises of the existence of a material safety data sheet (MSDS) for the substance. All materials decanted from the original purchase and storage containers are to carry workplace labels that identify the chemical, but contain less information. This applies to substances which are decanted for immediate use elsewhere in the building and to substances which are decanted and put aside for future use. An identifying name must be grease penned or otherwise affixed to all beakers and test-tubes of materials in use. This also applies to products of chemical reactions, which, if being kept longer than the immediate work period, must be provided with full labelling. Substances being used in tests of unknowns are to be labelled with a code, matching the container from which the sample was decanted. This code must be on the original container and allow instant access to full information regarding the substance.

Several problems may be encountered in ensuring correct labelling. Containers purchased prior to WHMIS regulations coming into effect may not have adequate labelling and difficulties may arise in contacting suppliers to obtain the correct labels. For example, one major supplier went out of the chemical supply business at the time the new regulations came into effect. Thus, it would be impossible to obtain supplier labels for bulk products obtained from that company. Determining precisely what constitutes a hazardous substance is another dilemma. No definitive list of such substances is available and a common solution is to trust suppliers to provide supplier labels and MSDS's for all materials that qualify. This means that teachers are forced to make decisions about the supplies of chemicals that were purchased prior to the WHMIS regulations becoming law. Where suppliers of old stock cannot be contacted or have gone out of business, the materials are to be disposed of. This, however, may lead to further problems regarding the costs and proper procedures for disposing of hazardous waste. Once bulk chemicals are labelled properly, adhering scrupulously to the regulations for labelling containers in use during classroom experiments may require extensive time expenditures to insure that all students are complying.

Second, teachers are to obtain and make readily available material safety data sheets (MSDS's) for every hazardous substance in the classroom and laboratory. These sheets list a complete description of the substance, all known dangers connected with its use, proper safety practices and equipment needed and first aid instructions should an accident occur. It was a requirement that the MSDS's be provided by the supplier from whom the substance was purchased, and that updated MSDS's be obtained from the supplier every three years for as long as the material is being stored or used at the school. Outdated MSDS's must be retained as records for 30 years.

A problem similar to that encountered in obtaining correct labels applies here. Locating suppliers of materials obtained before passing of the legislation might be difficult or impossible.

Third, teachers must prepare a plan for insuring that students are educated concerning use of MSDS's, correct labelling and safety practices for all procedures in which they are engaged. A plan for safety instruction is to be drawn up and revised annually. All previous safety education plans are to be kept on file for a minimum of 30 years.

With the exception of the annual update of written lesson plans and long-term maintenance of records, this part of the WHMIS regulations likely coincides with the safety units taught at the beginning of science courses, or preceding individual laboratory activities.

Rationale for the Study

The study was motivated, initially, by discussion with science educators regarding difficulties in fully implementing the WHMIS regulations while continuing to maintain an emphasis upon student laboratory work. The suggestion was made that full implementation, without a decrease in the amount of time which could be spent on student laboratory work, is feasible only in large urban schools that have the budget and staff to facilitate the inventorying, disposal, repurchase and information updating of the chemicals necessary to conduct specific experiments. These comments suggested that there would be value in an investigation of whether or not the WHMIS regulations, which have been in effect since October 1988, actually are being implemented by science teachers in Manitoba junior and senior high schools. If the regulations are being implemented, it would be of value to investigate relationships between the degree of implementation and the amount of student laboratory activity.

Also of interest to educators in Manitoba is whether or not rural teachers, and especially rural teachers at small schools, are at any disadvantage in terms of implementation of WHMIS regulations, or in terms of student laboratory activities. Accordingly, data that provide information on school location and size are included in the study.

There also appears to be a need to acquire data that could be used to produce profiles of select characteristics of rural and urban teachers and schools. These characteristics might indicate explanations for the difference should rural-urban differences in implementation occur.

Topics of the Study

This research is designed to examine several aspects of the implementation of the Workplace Hazardous Materials Information System (WHMIS) in junior and senior high school laboratories and classrooms throughout Manitoba. Questions investigated include the following:

1. whether Manitoba science teachers are aware of the existence of the WHMIS regulations,
2. to what degree they are knowledgeable about and actually implementing the regulations in their classrooms and laboratories,

3. whether WHMIS knowledge/implementation is related to rural as opposed to urban school locations and to school population size,
4. whether WHMIS knowledge/implementation is related to teacher and school characteristics, including an inquiry into any rural-urban differences in the distribution of these characteristics, and
5. whether the amount of student laboratory activity is related to WHMIS knowledge/implementation, also including rural-urban comparisons.

To assist the reader in locating and following the various themes of the study, the four main topic areas are standardized as follows:

WHMIS AND GENERAL SAFETY KNOWLEDGE/IMPLEMENTATION
SELECTED TEACHER AND SCHOOL CHARACTERISTICS
AMOUNT OF STUDENT LABORATORY ACTIVITY
RURAL OR URBAN LOCATION AND SIZE OF STUDENT POPULATION.

The broad topics subsequently are combined into the following areas of investigation:

1. KNOWLEDGE/IMPLEMENTATION OF WHMIS REGULATIONS AND GENERAL SAFETY PRACTICES
2. WHMIS AND GENERAL SAFETY KNOWLEDGE/IMPLEMENTATION COMPARED IN THE RURAL AND URBAN SECTORS AND IN SCHOOLS WITH DIFFERENT SIZE STUDENT POPULATIONS
3. RELATIONS BETWEEN WHMIS KNOWLEDGE/IMPLEMENTATION AND SELECTED TEACHER AND SCHOOL CHARACTERISTICS
4. SELECTED TEACHER AND SCHOOL CHARACTERISTICS COMPARED IN THE RURAL AND URBAN SECTORS AND IN SCHOOLS WITH DIFFERENT SIZE STUDENT POPULATIONS
5. RELATIONS BETWEEN AMOUNT OF STUDENT LABORATORY ACTIVITY AND WHMIS KNOWLEDGE/IMPLEMENTATION.
6. AMOUNT OF STUDENT LABORATORY ACTIVITY COMPARED IN THE RURAL AND URBAN SECTORS AND IN SCHOOLS WITH DIFFERENT SIZE STUDENT POPULATIONS.

Research Methodology

Because previous research does not exist on either WHMIS implementation in schools, or on factors related to implementation of any other aspect of curriculum implementation for Manitoba science teachers, this study involves many variables that might be associated with implementation. Information about the selected variables is obtained from a survey of a random sample drawn from all Manitoba junior and senior high school science teachers. Resulting data is analyzed to determine which of the variables are associated with implementation. Future studies may consist of more detailed statistical or ethnographic investigations of the significant variables in this study.

A mailed questionnaire was the chosen research instrument. Results of the questionnaire are tabulated and graphed to discern trends. Data are analyzed for statistical significance.

Theoretical Setting of the Research: The General Problem of Curriculum Implementation

Considerable attention has focused on factors that can either facilitate or impede implementation of a desired curricular change. The fact that there is often a discrepancy between curriculum as outlined or advocated by governing agencies, and curriculum in the daily activities of actual classrooms is noted.

Discussion regarding how discrepancies can be minimized traditionally focuses on ways in which the desired curriculum should be set up or planned in order to ensure that classroom implementation does take place. As it became obvious that even the best-planned curricula often are not realized or are vastly modified in classroom settings, however, attention shifted to factors outside of the printed curriculum. Initial studies emphasized the influence of interests outside the school, the effectiveness of inservice training, the characteristics of the administration, the students and the school. Recently, research has focused on the characteristics of the teachers who are expected to implement a curriculum.

In this latter area of study, attention recently has been given to the role played by the personal background that the teacher brings to the classroom in determining what implementation actually occurs as classroom "curriculum". Accompanying interest in the classroom teacher is a shift in the philosophy of implementation. This shift suggests that the focus of implementation should not be on how to get teachers to carry out the curriculum changes originating outside the classroom, but rather how to bring such changes in line with the realities of existing classroom practice. Researchers demonstrate both points of view.

Implementation of The Workplace Hazardous Materials Information System (WHMIS) in Manitoba Junior and Senior High School Science Laboratories

The implementation of WHMIS regulations may be difficult for science teachers owing to time and budgetary constraints. Furthermore, teachers are not a part of the planning of regulations and have no input into how the regulations might apply to their particular situation. As a result, it is possible that implementation is not widespread.

The survey used herein samples aspects of all three areas of WHMIS in order to determine the extent of WHMIS knowledge and implementation among junior and senior high school science teachers in Manitoba. Teachers also are questioned on whether or not they have a WHMIS inspection of their laboratory/classroom. In addition, a survey is made of laboratory accidents involving injury to students in order to determine the current level of safety for students.

Relationships between WHMIS Implementation and Teacher and School Characteristics

In response to the growing interest in the role of the teacher and the teacher's background characteristics in curriculum implementation, it was decided to investigate some areas of teachers' personal background that might relate their inclination to become familiar with and implement the WHMIS regulations. The study includes items on the teacher's sex, age, total years of experience in teaching, experience in teaching the particular grades and subjects currently assigned, total years spent at the current school, and academic background in both science subject matter and in professional courses related to science teaching methods and curricula.

The question of the role of school location and size is mentioned earlier. Other variables of the school environment that are considered of possible importance are the average student/teacher ratio and the availability of laboratory assistants.

Resulting profiles and determining associations between teacher background and implementation would help to identify specific areas of need should significant discrepancies in terms of implementation arise among various identifiable groups.

Relationship between WHMIS Implementation and Student Laboratory Activity

Following science curriculum reforms of the 1960's, emphasis was placed on student laboratory work as a desirable part of science curricula. It is viewed as a concrete, 'hands-on' element in teaching strategy, as a means to improved critical thinking and problem-solving abilities and as an end in itself as the actual "doing" of science. The question of whether or not student laboratory work achieves these goals lies beyond the scope of this inquiry.

This research is concerned with whether attempts to improve safety standards in school laboratories through the implementation of WHMIS regulations is related to the amount of student laboratory activity. Would teachers who are good implementers of the WHMIS regulations also be good implementers of student laboratory activity, or would fears of penalties resulting from non-adherence to WHMIS regulations coupled with difficulties in implementation of the regulations, inhibit teachers' abilities and desires to maintain current amounts of student laboratory activities? This part of the study investigates whether an earlier element of curriculum, the amount of laboratory activity, relates either positively or negatively to implementation of an element of curriculum demanded by an outside agency (Workplace Health and Safety).

REVIEW OF RELATED LITERATURE

WHMIS Regulations

Details of the legislation and derived regulations regarding the Workplace Hazardous Materials Information System (WHMIS) are found in two Manitoba Government publications: The Workplace Safety and Health Act: Being Chapter W210 of the Continuing Consolidation of the Statutes of Manitoba and Manitoba Regulation 52/88: Workplace Hazardous Materials Information System Regulation and Manitoba Regulation 53/88: Workplace Health Hazard Regulation: Being Regulations under the Workplace Safety and Health Act: Office Consolidation.

There are two manuals, WHMIS Education and Training Programs: Guidelines for Employers, Workers and Regulatory Agencies and WHMIS in Your Workplace, published by the Government of Canada, that outline the regulations and how they are to be implemented. These do not, however, apply specifically to schools and leave many questions peculiar to the school situation unanswered. More detailed, but still lacking specific references to the school situation, are the Manitoba Environment and Workplace Safety and Health (1988) publication, A Workplace Guidance Manual to the Hazardous Materials Information System (WHMIS): Manitoba Regulation 52/88 and the Manitoba Labour Workplace Safety and Health Branch (1990) publication, Program No.4: Introduction to the Workplace Hazardous Materials Information System (WHMIS).

An article in the February, 1991 issue of The Manitoba Science Teacher briefly describes the regulations and makes suggestions for implementation in schools. An undated publication of the Risk Management Department of the Manitoba Association of School Trustees entitled W.H.M.I.S.: Training Manual, is a summary of the Manitoba Government publications. It does not discuss the special problems of implementation for school laboratories.

Possible Effects of Implementation of WHMIS Regulations On Student Laboratory Activity

The U.S. Occupational Exposures to Hazardous Chemicals in Laboratories legislation became effective January 31, 1991. The agency in charge of these regulations is the U.S. Department of Labour, Occupational Safety and Health Administration (OSHA) (Gerlovich, 1992).

Concerns regarding its effect on school laboratory activity in the United States had been expressed in science education journals prior to the enactment of this legislation, . An article by Beach and Stone in the July, 1988 edition of The Journal of Chemical Education is representative of these concerns. The article is a statement of the collective opinions of 22 high school chemistry teachers from across the United States regarding the survival of high school chemistry laboratories. They make the point that it is desirable for high school graduates to possess, as a life skill in modern society, the ability to deal safely with potentially dangerous chemicals that may be components of compounds in daily use. This could not happen if all such dangerous chemicals are eliminated from the laboratory. They present, as an example, the picture of a student encountering unlabelled benzene later in life, perhaps in gasoline or industrial cleaners, yet lacking the ability to identify it and take the necessary steps to ensure protection from its hazards. In addition, they point out that current school laboratory safety procedures minimize accidents to the point where the school laboratory is a safer workplace than the home kitchen. The authors suggest that even though there is a lack of research into the academic functions of school science laboratories, the intensity of the interviewed teachers' opinions regarding the importance of preserving and even expanding student laboratory activities suggests that this is an area of curriculum deserving of further study.

Concern also is raised that with classroom time already full, the inclusion of further safety training would result in the deletion of current content in order to make room for the new work. Everett and DeLoach (1988) discuss this issue while investigating the feasibility of introducing a laboratory safety course into the study of chemistry.

S.P. Faulkner (1993:27), writing in The Science Teacher, also assumes that additional safety measures in school science laboratories will be accompanied by modification or complete elimination of student laboratory activity. "As our awareness of laboratory safety is increasing and our science budgets are decreasing, many teachers are scrambling to find safer, less expensive ways of teaching chemical concepts, or abandoning hands-on activities completely". He goes on to discuss some modified experiments that may be of use to teachers in this predicament.

These opinions suggest that an investigation into possible relationships between the amount of student laboratory activity and the degree of implementation of WHMIS regulations in Manitoba might prove useful in either supporting or casting doubt upon these concerns.

WHMIS and the Legal Situation Regarding School Laboratory Accidents

As mentioned in the introduction, concerns for workers', or in this case, students' health and safety led to the creation of legislation to provide guidelines for what constitutes "reasonable" behaviour in terms of giving adequate protection to those people involved in intrinsically hazardous situations. These regulations provide a measure of safety for the workers (students) who would be better trained and informed and for the employers (teachers and school divisions) who would have evidence of having taken steps to maximize safety should an accident and related litigation occur. Laws, however, are subject to differences in interpretation that could lead to variations in how the resulting regulations are carried out.

A few articles concerning litigation and school science laboratories have been produced in the United States. The most recent appeared in The Journal of Chemical Education (Gass, 1990). This article notes that

in order to establish negligence on the part of a teacher or school, one must demonstrate that "reasonable" care, defined as the steps taken by any "reasonable" person to ensure safety, was not taken. Furthermore, the workplace might inherently contain risk so long as that risk was not "unreasonable".

What constitutes "reasonable" behaviour and conditions? Would an absence of accidents resulting in injury to students indicate that "reasonable" precautions are being implemented by teachers? Would teachers be satisfied that existing safety measures coupled with their accident record are sufficient insurance against legal problems and thus not be motivated to implement further time-consuming measures? On the other hand, cases of litigation against teachers or schools, especially if successful for the plaintiff, suggest a definite need for further safety regulations, such as those mandated by WHMIS legislation, to be in place.

The case studies presented by Gass (1990) to demonstrate typical court judgements generally are not recent, with many cases dating back as far as 1925. The author, however, does not indicate the number of negligence cases brought against school science teachers for any time period or geographical area.

This lack of historical records led to a search for instances of litigation against Manitoba teachers or public schools. None were found, and a decision was made to include some method of inquiring into accident records of current Manitoba science teachers as part of the research. The object is to establish some knowledge of the degree of student safety in Manitoba school science laboratories and to assess how great the threat of litigation might be.

According to the interpretation in provincially produced handbooks regarding the implementation of WHMIS legislation, schools are considered workplaces in the same sense as any commercial establishment, students are considered workers and teachers and administrators are considered employers (Workplace Safety and Health Act, Chapter W210, 1987, p.3). If this implies that implementation of the regulations applies to schools exactly as to all other workplaces, teachers have no choice but to comply with the regulations or face penalties. One questions whether or not this interpretation would change if it was 1) demonstrated that existing safety measures or adaptations of the regulations taken by science teachers are adequate and "reasonable" enough to allay fears of litigation in the event an accidental injury should occur, and 2) that the situation existing in school laboratories is sufficiently different from that in industrial, commercial and government research establishments to make identical implementation in schools difficult and costly enough to endanger student laboratory activity. No literature was found dealing with the possibility of adaptation of existing laws.

If there is a serious conflict between the implementation of the existing WHMIS legislation and the implementation of student laboratory activity some believe that further investigation should take place into having the legislation reinterpreted in the case of schools(Connelly and Clandinin, 1988). A lack of implementation may imply a problem, not in the classroom, but in the material to be implemented or in the reasons for its implementation. If practice does not reflect theory, theory is at fault (p.95). This approach counters the more traditional view that if practice does not reflect theory, more intervention is needed to bring classroom practice into line with theory.

In this research, intervention occurs in the form of inspections for implementation and imposition of penalties where implementation is not enforced. Less direct intervention may consist of setting up conditions conducive to implementation. This approach to analysis of a lack of WHMIS implementation leads to questions of whether the innovation actually is necessary.

There are two possible negative effects of the legal necessity requiring WHMIS implementation in school laboratories. One is continued student laboratory activity accompanied by non-implementation or low implementation of WHMIS creating the risk of penalties for failed inspections or litigation where the lack of adherence to WHMIS regulations could be judged as a lack of reasonable care on the part of the teacher. The other negative result also would be a non-implementing situation. The threat of penalties resulting from

non-compliance with WHMIS might be avoided through a reduction or total elimination of student laboratory activities in order to eliminate the need for those aspects of WHMIS implementation that prove too costly or otherwise inconvenient. Because no research currently either confirms or denies a negative effect of WHMIS implementation on student laboratory activity, the present research investigates factors that could facilitate implementation if it is determined that such implementation is desirable and not yet at acceptable levels.

The Importance of Student Laboratory Activity in Science Curricula

Journal articles either extol the virtues of the student laboratory, or are prescriptive in suggesting specific activities and safety tips. Blosser's (1983:165, 167) review of work done on the role of the laboratory indicates that the literature is opinion-based rather than research-based. Where research has been completed, it is "usually an individual's first attempt at research" yielding mixed results and lacking any follow-up work.

Blosser cites a national survey by Weiss (1978) and case studies by Stake (1978) for providing the information that there generally is less student lab activity in the United States than is deemed desirable. In these studies, teachers attribute difficulties in classroom management and in obtaining needed supplies as the primary reasons for the discrepancies. White and Tisher's (1986) contribution on science teaching in the Handbook of Research on Teaching confirms that little research has been conducted into the nature or effects of student laboratory activities.

In spite of the lack of research confirming the importance of student laboratory activity, writings throughout the field of science education continue to assume the importance and desirability of such activity. The complete revamping of junior and senior high school science curricula in the United States in the 1960's was underlain by the assumption that student laboratory work should be central to the teaching of science. Shulman and Tamir's 1973 review of research on science teaching states that the laboratory occupies "a central role" in all of the new science curricula produced in the United States in the 1960's. They speak of a shift of emphasis from laboratory activity as confirming or demonstrating lecture material to laboratory activity being the learning process itself. They then go on to say that this shift is based on opinions of the course designers and not on empirical research. What research has been carried out regarding efficiency and implementation gives contradictory results in regard to efficiency and indicates very low implementation.

Journal authors do, however, subscribe to the importance of laboratory work. Concern with maintaining and increasing student laboratory activity has led to concern regarding the implementation of any new classroom material, such as additional safety regulations, which might reduce the amount of student laboratory activity. The desirability of extensive student laboratory activity is assumed for this study and an attempt is made to obtain a measure of the amount of such activity.

Teacher Characteristics Related to Implementation

Olstad and Haury (1984) reported that little research had been done on teacher characteristics related to program implementation prior to 1982. They felt that this situation was in need of remedy "Since it is the teacher alone in the classroom who ultimately determines the quantity and quality of science instruction to which students are exposed, it seems critically important to study the variables influencing teacher behaviour" (p.238).

Brosnan et al. (1994) state that one of the most important motivating factors for implementation of new material or methods is dissatisfaction on the part of the teacher with the materials or methods currently in use. Feldman and Atkin (1993) state that teachers need to know that their efforts at implementation are worthwhile and suggest that more research be directed toward providing teachers with evidence of the value of the innovations as well as the means to make implementation easier.

Rafferty (1992) also concludes that a predisposition or intent of the teacher to implement is extremely important. Pratt (1980:408-409) cites the importance of the teacher being personally aware of the value of the change. One way in which this can come about is through personal contact with other teachers who feel that the change is important.

The importance of social interaction as an aid to implementation is stressed frequently in the literature. According to Brosnan (1994:37), once the initial motivation for change is established, the greatest need of the teacher in the process of implementation is "information dealing specifically with classroom practice"). This is obtained most effectively through interaction with other teachers or advisors.

Rafferty's (1992) list of variables that are significant in facilitating curriculum implementation include the influence of supportive cooperating teachers. In fact, the lack of such influence restricts implementation. Fullan and Stiegelbauer (1981:132), state that:

> "There is no getting around the primacy of personal contact. Teachers ... need to have one-to-one and group opportunities to receive and give help and more simply to converse about the meaning of change".

They cite work by Huberman (1990, 1991) that indicates the need to increase the number and quality of colleagues or experts to which individual teachers could turn as they are engaged in implementation. Fullan and Stiegelbauer (1991) theorize that the lack of a "common technical culture" and the resulting isolation of classroom teachers is the source of many implementation failures.

Smorodin (1984) investigated the role of personal contact in successful curriculum implementation. In this case, personal contact was provided by visits to the implementing teacher by a curriculum co-ordinator. Smorodin reports a statistically significant relationship with the degree of implementation increasing with increased visits of the co-ordinator. James and Hall (1981:480) also conclude that: "...information alone is not enough to affect utilization...interpersonal or social influences are prime determinants of the use of an innovation."

A number of writers discuss the role of the teacher's subject-matter background. Most consider subject-matter as that information which is specific to the implementation. This knowledge could be obtained from inservice training. A few also credit general academic background for providing confidence and the mental facility to deal with new ideas and techniques.

Slaugh's (1984) study on the implementation of a new business education curriculum concludes that the teachers who have extra inservice training perceive fewer barriers to implementation than do other teachers. She comments that her work supports earlier work by Fullan and Pomfret (1977) which indicates that inservice training in excess of the usual amount is responsible for increased use of curriculum innovation. Smorodin (1984) reports that the most important variable for implementation other than personal contact is background in the particular subject or content to be implemented.

Rafferty's (1992) list of influences which facilitate implementation include adequate subject matter preparation. In the context of the list, preparation appears to refer to subject matter particular to the implementation in question. Elsewhere in the article, however, she argues for the value of a strong general education in increasing the complexity of mental functioning.

> "A basic assumption is that humans behave according to the level of complexity of their mental structures. Less sophisticated cognitive development yields rigid, concrete and less adaptive behaviour during problem-solving situations. Teaching involves hundreds of problem-solution scenarios ... implications are obvious" (Rafferty, 1992:6).

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While Fullan and Stiegelhauer (1991) report that little research has been done on the impact of academic and professional training on teacher behaviour, Toch (1991) blames the lack of implementation of science curriculum reforms of the 1980's on a lack of academic background in university science.

If there is validity in Connelly and Clandinin's (1988) thesis of the importance of each teacher's personal practical knowledge to what occurs on a daily basis in that teacher's classroom, it is reasonable to expect that teachers who are exposed to more laboratory work as students or in the workplace prior to becoming teachers, are more confident and capable in this area and thus are more inclined to implement changes in their own class laboratories. Alternately, those teachers who have not had the opportunity to make laboratory work a part of their own background knowledge might be more inclined to avoid its use in their classrooms or avoid making any changes to established practices.

Finding sufficient time for implementation is a problem for teachers. Rafferty (1992) reports that both a need for fewer preparations and more planning time encourage implementation. This view is supported by Fullan and Stiegelhauer (1991). Slaugh (1984) cites lack of time and lack of clerical assistance which would, if available, presumably aid in creating more time for implementation, as perceived barriers to implementation.

The question of whether or not teachers who have more experience in teaching the subjects and grade levels they are assigned also have more time for implementation of innovations is considered. McLaughlin and Marsh (1978) report that years of experience relates negatively to implementation of a project and that "... more experienced teachers also [are] less likely to change their practices..." (p.84).

The tendency to neglect the role of the classroom teacher in implementation studies is addressed by Feldman and Atkin (1993:287) who hypothesize that

> Research in science education may have little effect upon classroom practice because there is not much research in the USA on science teachers or the dilemmas they identify as central to their work. In fact, in much of the research, even that which is said to be done collaboratively with teachers, the teachers seem to be invisible.

The foregoing comments suggest the importance of investigating some aspects of teachers' personal background that might relate to their inclination to become familiar with and implement the WHMIS regulations. This study includes items on the teacher's sex, age, total years of experience in teaching, experience in teaching the particular grades and subjects currently assigned, total years spent at the current school, and academic background in both science subject matter and in professional courses related to science teaching methods and curricula. Additional variables of the school environment that are considered of importance to implementation efforts are the average student/teacher ratio and the availability of laboratory assistants. Hopefully, these profiles, as well as determining the existence of relationships between teacher background and implementation, also will identify specific areas of need should significant discrepancies in terms of implementation arise among identifiable groups.

Rural and Urban Locations and Student Population

There has been considerable controversy in Manitoba in the past few decades regarding the desirability of maintaining small rural schools as opposed to bussing students from small communities to larger centralized schools. Some argument revolves around the notion that the increased resources available at central schools result in hiring of better-prepared teachers. However, there are few studies that compare differences in teachers at rural and urban, and small and large schools.

The most recent study of rural-urban differences among secondary science teachers is a 1992 effort conducted by Carlsen and Monk. In a survey of 456 middle and secondary science teachers in the United States, they conclude that there are few differences, but they do note the following exceptions: 1) rural teachers, on average, have taken fewer science courses and fewer science methods courses, 2) rural teachers have less experience and are more likely to have taught subjects other than science, and 3) rural teachers are less likely to have majored in science and less likely to have graduate degrees.

The only Canadian study relating to this issue is a survey of 35 rural and 16 urban biology and life science teachers in Southern Alberta (Guay, 1980). The major differences are that "teachers of biology and life science courses in urban locations reported more specialized instructional assignments than their rural counterparts, especially at the senior high level" and a "...trend for increasing specialization at the senior levels and in the urban areas" (p.5). Guay also reports that junior high teachers are assigned multiple subjects more often, especially in rural schools. "In rural junior high locations almost every subject in the curriculum was included in at least one teacher's assignment." Guay also found that "... urban teachers were usually better prepared academically than were rural teachers" (p.25). The only other reported difference is that urban classes are larger than rural classes.

While differences are confined to a few variables, these represent areas which are cited as important to program implementation. Critics of small rural schools point to findings such as teachers being assigned numerous subjects as indicating an inferior quality of teaching in these schools.

However, not all education scholars are in agreement with this stand. Colton (1981) writes that rural students actually are better off as smaller classes allow them to be treated as individuals. Furthermore, limited resources have not been linked to inferior science education. He states that only if research shows that teachers who are subject specialists produce better education than generalists would detractors of small rural schools have a point. No such results existed at the time his article was written. Colton speculates that the rural teacher with a broad background and classes in a variety of subjects might well be in a position to present more in the way of integrated, interdisciplinary courses, which may be more relevance to the students. This opinion is repeated by Edington (1983) who, in a report for the United States Senate Budget Committee, states that one of the special needs of small, rural schools is for teachers with good science backgrounds as generalists rather than specialists. The rationale he offers is that should low enrolment force a school to drop the total number of science teachers, the teacher with a strong general background would be more likely to be able to provide quality education in a number of areas than would a teacher who had concentrated in only one area.

Colton also discusses the problem of professional isolation faced by teachers in small rural communities. As noted earlier, several researchers have concluded that program implementation is linked strongly to teacher contact with one or more individuals in a position to offer knowledge and practical help. Colton suggests that "What is so successful elsewhere and is so badly needed here is a sound advisory service, so that the teacher will be helped in his own classroom to put new ideas into practice" (p.39).

It is beyond the scope of this research to examine the educational output of rural schools. However, it is feasible to include a survey of school location and size and to check for any relations or notable differences in terms of either WHMIS implementation or the amount of student laboratory activity for teachers from these schools. In addition, a profile of the average rural and urban teacher is created in association with the characteristics studied for implementation.

RESEARCH PROBLEM, DESIGN AND PROCEDURES

The problem investigated consists of determining whether any implementation of WHMIS regulations is occurring, whether implementation is related to any of several selected teacher and school characteristics

and whether implementation is related to the amount of student laboratory activity. The following components are investigated in the study knowledge and implementation of WHMIS and relationships with other variables:

1) the degree of knowledge about WHMIS regulations and the degree to which they are implemented in junior and senior high school science laboratories and classrooms across Manitoba,
2) the relationship between WHMIS knowledge and implementation and selected teacher and school characteristics,
3) the relationship between WHMIS knowledge and implementation and the amount of student laboratory activity, and
4) the relationship between WHMIS knowledge and implementation and either or both a rural location and a small student population.

The two independent variables that are identified in the fourth component, while actually a subset of the school characteristics in the second component, are considered separately as the degree of implementation for teachers working in small, rural schools is of special interest in this study.

Variables Measured For Each Component of the Study

Four WHMIS-related (dependent) variables are reported for each teacher surveyed:

- awareness of the existence of the regulations
- a category indicating the amount of knowledge of and implementation of WHMIS regulations
- teacher's record of laboratory accidents involving students and whether accidents are judged to be preventable through implementation of WHMIS
- inspection for WHMIS implementation

School-related (second and fourth components) and teacher-related (second component) (independent) variables that are assessed include the following:

The school related variables are:

- rural or urban location
- size of student population
- average number of students per class
- access to laboratory assistants

The teacher related variables are:

- sex
- age
- total years of teaching experience
- length of time (in years) at current school
- subjects and grades currently taught
- experience in specific grades and subjects
- university credit hours in science subjects, and
- credit hours of professional training in science methods and curriculum.

Student laboratory activity-related (dependent) variables (third component) for each teacher surveyed include the following:

- amount of student laboratory activity
- changes in the amount of student laboratory activity over the past five years
- specific laboratory changes resulting from implementation of WHMIS regulations, and
- perceptions of effects of any such changes.

Data for all of the listed variables were obtained from teachers' responses to a mailed questionnaire (see Survey Instrument).

Associations Tested for Between Variables

Associations Between WHMIS Knowledge and Implementation (first component) and School Location or Size (fourth component)

Comparisons between WHMIS knowledge and implementation and the independent variables of school location, size of student population, occurrence of accidents and occurrence of WHMIS inspections are investigated. Where significant associations occur between WHMIS knowledge and implementation and the latter two variables, the independent variable is tested for significant rural-urban and school size associations.

Associations Between WHMIS Knowledge and Implementation (first component) and Selected Teacher (second component) and School Characteristics (fourth component)

The teacher categories for degree of WHMIS knowledge and implementation are compared with each of the listed teacher and school characteristics. As in the previous section, where significant associations are discovered, the independent variables are subsequently treated as dependent variables and compared by school location and size of student population.

Associations Between WHMIS Knowledge and Implementation (first component), the Amount of Student Laboratory Activity (third component) and School Location and Size (fourth component)

The categories for WHMIS knowledge and implementation are compared to the categories for student laboratory activity, to overall changes in the amounts of student laboratory activity and to changes specifically resulting from the implementation of WHMIS regulations. Where significant differences are found, further investigations are made regarding the association of the variables in question to school location and size.

Survey Instrument

No instruments appropriate for this study were found. Consequently, the questionnaire used was prepared by the author and her graduate advisor. The result is an instrument consisting of three sections. In section 1 the questions relate to teacher profiles and school size and location. Teacher background information was obtained, including sex, age, years of teaching experience (in total) and in the grade levels and subject areas now being taught, total credit hours obtained in university science subjects, and total credit hours of professional training in science methods and curriculum. Additional questions dealt with the school location, student population, and grades offered at the school where the teacher is employed.

Questions in Section 2 concerned the amount of student laboratory activity along with factors that the teachers perceived as limiting student laboratory activity. Included were charts to be filled out for each class taught, with the actual number of student labs completed, an estimation of the percentage of classroom time devoted to lab work, recent changes in the amount of student work and perceived causes of change. Section 2 also included a checklist on which the teacher indicated all items that he or she believed made implemen-

tation of laboratory work difficult. Questions regarding the availability of laboratory assistants and the number of students per class were included.

Section 3 involved questions related to the teacher's knowledge of WHMIS, implementation of WHMIS and accident record. The questions on WHMIS implementation were designed to sample all three critical areas as outlined by the provincial regulations manual; (1) awareness of need for and use of specific types of labels in specific situations, (2) availability of updated material safety data sheets (MSDS's), and (3) a well-thought out and annually recorded plan for informing workers (in this case, students) of all they would need to know to insure their safety. Safety training includes the use of labels and MSDS's, information about the particular hazards of substances to be used, and information about special clothing, equipment and procedures required. In addition, this section obtained information regarding changes in chemical purchasing and changes in student laboratory activities resulting from WHMIS implementation. The teacher's laboratory accident record also was surveyed.

Testing of the Instrument

The questionnaire was pre-tested and evaluated by seven science teachers from Brandon junior and senior high schools. They indicated that for the most part it was easily understood, unambiguous and easily answerable. Questions were revised when comments suggested difficulty in understanding or interpretations. The revised questionnaire was submitted for the inspection of three individuals who are professionally involved in survey research. All indicated that the instrument appeared sound. The questionnaire was submitted, along with a copy of the proposed cover letter, to the Brandon University Research Ethics Committee which granted final approval for the research.

Population and Sample

The population studied includes all junior and senior high school science teachers in Manitoba as of autumn, 1993. A list of names was obtained from the Certification Branch of Manitoba Education and Training, and contained 659 rural and 502 urban teachers. It included teachers at reserve and private schools as well as public schools. Letters requesting permission to conduct the survey, return envelopes and approval forms were mailed to the superintendents of all school divisions and districts included in the survey, as well as to all principals of independent and private schools.

Seventy-eight percent of rural school divisions, 78 percent of urban school divisions and 23 percent of private schools permitted teacher participation in the research. The teachers were classified as urban if their school had a Winnipeg address or as rural if the school had any other address. This classification conformed to definitions of rural and urban used by the Rural Development Institute. A computer-generated random sample of 300 urban teachers and 300 rural teachers was drawn from these groups. Each teacher was mailed a questionnaire, cover letter, request for results slip and stamped return envelope in March, 1994.

Responses were collected until the end of the school year in June, 1994. The response rate was approximately 33 percent and yielded a sample consisting of 128 rural and 91 urban teachers, for a total of 219 responses.

Data from the questionnaires are recorded in spreadsheets. This permits counts to be made of the various factors under consideration, groupings of two or more factors where needed, development of frequency tables and graphs, and association analysis.

REDUCTION AND ANALYSIS OF DATA

Non-parametric statistical tests are used because data are nominal and ordinal. The chi-square test is most suitable for the data.

The returned questionnaires are divided into groups of rural and urban teachers. Further subdivision is based on school population with groups for schools with student populations of 1-49, 50-99, 100-199, 200-399, 400-999, ≥1000, and teachers who did not answer the question on student population. Data sheets for each rural and urban school size consist of a series of columns in which the responses to the various items of the questionnaire are listed. Data are grouped to facilitate the use of the non-parametric chi-square test.

Analysis of WHMIS-related variables

Teachers could respond either "yes" or "no" to the question of whether they are aware of the WHMIS regulations. The frequencies of "yes" and "no" answers is tabulated. Each teacher used a check mark to indicate implementation of each of 16 items, and 1 free response listed in a table in the questionnaire. This allows a count of the total number of checks for each teacher. Each check is scored as "1" and the total number provides the raw scores for WHMIS knowledge and implementation and "general safety" knowledge and implementation.

In a few cases, the teachers' responses indicate that certain items are not applicable to their situations. In these cases, the WHMIS category is determined on the basis of the percentage of positive responses in relation to the total number of items which do apply.

Responses to the WHMIS items are divided into two groups. The teacher's score on the group of 10 directly relevant items is considered the most accurate indicator that the material introduced into the curriculum by WHMIS regulations is understood and implemented. Six other items, while important in WHMIS regulations, are designated as "general safety" items because they consist of knowledge and behaviours which were advocated for laboratory safety prior to the advent of WHMIS, and might be in place without knowledge of WHMIS by the teacher. Items designated "general safety" and specific reasons for their deletion from the WHMIS implementation score are as follows:

> Questions that pertain to teaching safety rules at the beginning of each science course and at the beginning of each laboratory activity are deleted. Such behaviour has been recommended procedure in science methods.
>
> General safety classification is given to the presence of MSDS's in the laboratory and the presence of supplier labels on bulk purchases. The supplying of both of these items is now the legal responsibility of the chemical supplier. Thus a teacher with no knowledge of WHMIS could have both of these items in place.
>
> The existence of a chemical inventory is considered under general safety. Prior to the WHMIS legislation, maintenance of a chemical inventory was implemented to facilitate planning and restocking.
>
> Rules regarding the labelling of chemicals to be used in identification of unknowns also is put into the general category. This might elicit a positive response, even from those teachers who are completely or largely ignorant of other aspects of WHMIS, simply because these teachers still need a code in order to evaluate student achievement in correctly identifying the substances.

Finally, raw scores are combined into categories in order to facilitate statistical analysis. Chi-square testing requires that groups have enough members to avoid cells having a zero expected frequency or more than 20 percent of the cells having an expected frequency of less than 5 (Siegel, 1956, p.178).

Categories for the 10-item WHMIS measure, the 6-item general safety procedures measure and the combined 16-item measure are defined as follows:

No. positive responses (raw score)	WHMIS category
0	0
1-2	1
3-4	2
5-7	3
8-9	4
10	5

No. positive responses (raw score)	General Safety category
0	0
1	1
2	2
3-4	3
5	4
6	5

Combined WHMIS and General Safety categories are computed from the 16-item scores as follows:

No. positive responses (raw score)	Combined category
0	0
1,2,3	1
4,5,6,7	2
8,9,10,11	3
12,13,14,15	4
16	5

Data from computed tables are collapsed into appropriately-sized tables for chi-square statistical analysis.

Whether or not inspection for WHMIS had taken place is measured by a frequency count where a teacher checking any parts of the five categories involved is counted as a "yes", and a teacher checking "none" is listed as a "no".

The effectiveness of existing safety practices is determined by teachers' reports of accidents that involved injury to students. Counts are made of teachers checking "yes" (they had at least one such accident) and of those checking "no". This is followed by a count of each type of accident checked off by the affirmative respondents. For teachers reporting accidents, a count is then made of the number who considered the accident preventable by implementation of WHMIS regulations. A list is made of their reasons for considering or not considering the accident to be preventable. Questions regarding any litigation following an accident are included as a check on the severity of the accident.

Analysis of Selected Teacher and School Characteristics

Columns listing personal and professional characteristics for each teacher permit counts of the number of male and female teachers, and averages to be computed of the teachers' ages and years of teaching experience.

Categories indicating the degree to which teaching experience and academic background match the grades and subjects currently being taught are required to accommodate the chi-square testing and are assigned as follows:

Average Number of Years Experience in the Subjects and Grades Currently Taught	Category
1-2 years	1
3-9 years	2
10 or more years	3

Average Number of University Credit-Hours in the Subjects Currently Taught	Category
0 credit hours	0
3-15 credit hours	1
18-27 credit hours	2
30 or more credit hours	3

In the case of grades 7 through 10, where only general science is taught, the teacher's total number of credit hours in all sciences is used as the measure.

Teachers were asked to report the number of students in each class taught. For each teacher, an average is then taken of all class sizes. School location (rural or urban) and population were determined by direct questions.

Analysis of Student Laboratory Activity

It is necessary to combine teachers into categories in order to complete statistical analysis for student laboratory activity. Categories are set as follows:

Percentage of Class Time Devoted, on Average, to Student Laboratory Activities	Category of Student Laboratory Activity
0 - no student labs done	0
1%-24%	1
25%-49%	2
50%-74%	3
75%-100%	4

In the case of grade 11 and 12 teachers of specialized subjects, it is possible also to compare the actual number of student laboratory activities completed with the number recommended by the Provincial Curriculum Guides. Figures used for comparison are as follows:

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Subject and level	Number of Laboratory Activities Recommended
Biology - 200	20
Biology - 201	20
Biology - 300	21
Biology - 301	18
Chemistry - 200	8
Chemistry - 300	8
Physics - 200	8
Physics - 300	8
Physical Science - 201	15
Physical Science - 301	15

Categories of the number of student laboratory activities as a percentage of the number recommended are then set as follows:

Percentage of Recommended Laboratory Activities	Category
0 - no student labs done	0
1%-24%	1
25%-49%	2
50%-74%	3
75%-99%	4
>100%	5

These categories are similar to those used to measure student laboratory activity as a percentage of time. Category 5 was added as it is possible for a teacher to exceed the recommended number of laboratory activities.

Recent changes in student laboratory activity are assessed by a count of the number of teachers who checked each option offered on the questionnaire. Options offered are: 1) an increase in the amount of student laboratory activity, 2) a decrease, 3) no change, or 4) NA for those teachers who had not taught that particular subject and level long enough to experience changes. When a teacher reported different changes for different classes, an overall average direction of change was calculated.

Teachers were asked if any changes have occurred as a result of WHMIS implementation, to describe such changes and to evaluate the effects of the change on plans for students' learning. The number of teachers reporting changes as well as the number who saw the changes as detrimental to student learning are tabulated. Lists are made of the types of changes reported.

Null Hypotheses for Chi-Square Tests

The following hypotheses are tested statistically. Chi-square values equal to or exceeding those required for $p=0.05$ are required to reject the null hypotheses. Null hypotheses are identified by study components. Tests based on sub-samples are reported only if the original test results indicate significant differences in the original groups. Associations between size of student population and other variables are made only where there are significant differences between the rural and urban sectors in preliminary analyses.

Null hypotheses (Ho) for tests of association between WHMIS and General Safety Knowledge and Implementation and School Location and Student Population

Ho: There is no difference in the numbers of rural and urban teachers in each 10-item WHMIS category.

Ho: There is no difference in the proportions of rural and urban teachers who are unaware of the WHMIS regulations.

Ho: There is no difference in the 10-item WHMIS categories of teachers having experienced laboratory accidents involving injury to students and the categories of teachers who reported no such accidents.

Ho: There is no difference in the proportions of rural and urban teachers, who have experienced laboratory accidents involving injury to students.

Ho: There is no difference in the 10-item WHMIS categories of teachers who have had WHMIS laboratory inspection and teachers who have not been inspected.

Ho: There is no difference between rural and urban teachers in terms of the number who report having WHMIS laboratory inspection and those who have not.

Ho: There is no difference in the 10-item WHMIS categories among teachers at schools with different size student populations.

Ho: There is no difference in "general safety" categories between rural and urban teachers.

Ho: There is no difference in the combined score categories between rural and urban teachers.

Null Hypotheses (Ho) for Tests Relating WHMIS Knowledge and Implementation to Teacher Characteristics and School Characteristics

Teacher Characteristics:

There is no difference in the 10-item WHMIS categories:

Ho: between male and female teachers.

Ho: among teachers in different age groups.

Ho: for teachers with different amounts of teaching experience.

Ho: for teachers who have taught at their current school for different lengths of time.

Ho: among teachers who have taught different grades over the past two years.

Ho: for teachers with different academic backgrounds in university science courses.

Ho: for teachers with different amounts of professional training in science methods and curriculum.

School Characteristics:

There is no difference in the 10-item WHMIS categories:

Ho: for teachers with different average class sizes.

Ho: for teachers with access to full-time, part-time or no laboratory assistants.

Null Hypotheses (Ho) for Tests of Association between Selected Teacher and School Characteristics and School Locations and Student Populations

Teacher Characteristics:

There is no difference between rural and urban teachers in terms of:

Ho: proportion of male and female teachers.

Ho: age groups.

Ho: teaching experience.

Ho: length of time at current school.

Ho: grades taught over the past two years.

Ho: academic backgrounds in university science courses.

Ho: amount of professional training in science methods and curriculum.

School Characteristics:

There is no difference between rural and urban schools in terms of:

Ho: size of student population.

Ho: average class size.

Ho: access to laboratory assistants.

Null Hypotheses for Tests of Association between WHMIS Knowledge and Implementation and the Amount of Student Laboratory Activity

Ho: There is no difference in 10-item WHMIS categories for teachers devoting different percentages of classroom time to student laboratory activity.

Ho: There is no difference in 10-item WHMIS categories for grade 11-12 teachers who have different percentages of the provincially-recommended number of student labs.

Ho: There is no difference in the 10-item WHMIS categories of teachers reporting student laboratory changes as a result of WHMIS regulations and teachers reporting no such changes.

Ho: There is no difference in the 10-item WHMIS categories of teachers reporting an overall decrease in student laboratory activities and the WHMIS categories of teachers reporting either no change overall or an overall increase in student laboratory activities.

Ho: There is no difference in the frequency with which teachers reporting WHMIS-related changes to student laboratory activity also reported a decrease in laboratory activity and the frequency with which teachers who did not report WHMIS-related changes reported a similar decrease.

Null Hypotheses for Tests of Association between the Amount of Student Laboratory Activity and Rural-Urban Locations, and Size of School Student Population

Ho: There is no difference between rural and urban teachers in the percentage of classroom time devoted to student laboratory activity.

Ho: There is no difference among teachers at schools with various size student populations in the percentage of classroom time devoted to student laboratory activity.

Ho: There is no difference between rural and urban teachers of grades 11 and 12 in the number of labs completed as a percentage of the number recommended for that particular course by the provincial curriculum guides.

Ho: There is no difference among grade 11 and 12 teachers at schools with various size student populations in the number of labs completed as a percentage of the number recommended for that particular course by the provincial curriculum guides.

Ho: There is no difference in the number of rural compared to urban teachers who report changes in their student laboratory activity as a result of the implementation of WHMIS regulations.

Ho: There is no difference in the number of rural compared to urban teachers who report overall decreases in student laboratory activity.

RESULTS

Knowledge and Implementation of WHMIS Regulations and General Safety Items

Percentage of Teachers Who Had Heard About the WHMIS Regulations

One hundred and ninety-five (89 percent) of the 218 teachers who responded to the question on whether or not they are familiar with the WHMIS regulations answered positively. The remainder indicate that they had not yet heard about the regulations.

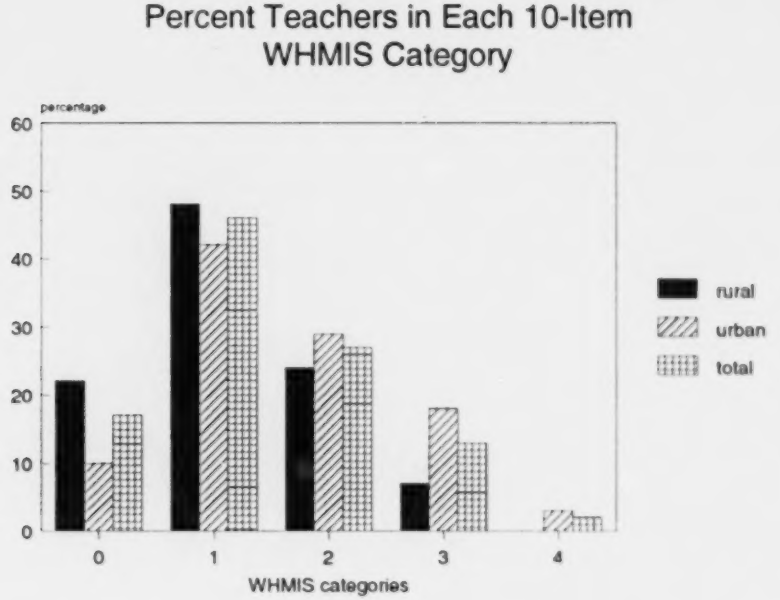
Teachers' scores on the 10 items that measure knowledge and implementation of WHMIS regulations are low. Of the 201 teachers who fully answered this portion of the questionnaire, none have a perfect score and only 12.5 percent obtain a raw score of 50 percent or better (categories 3 and 4). The majority fall into category 1 or category 2 (Table 1 and Figure 1).

Table 1. Total number of teachers in each WHMIS category

	WHMIS Categories							
	0	1	2	3	4	5	DNA[1]	TOTALS
TOTALS	33	91	52	23	2	0	16	219

Figure 1

Teachers' Knowledge and Implementation of WHMIS Regulations



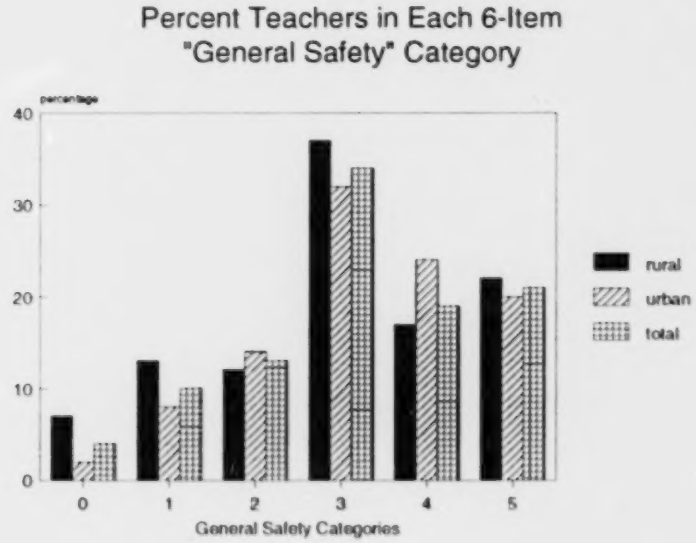
Teachers' Knowledge/Implementation of "General Safety" Items

Scores on the six general-safety items are considerably higher (Table 2 and Figure 2). Twenty percent of the 213 teachers completing these items receive a perfect score and 53.5 percent scored in categories 3 and 4. Only 5 percent received a zero score while the percentages in categories 1 and 2 fell to 10 percent and 12 percent respectively.

Table 2. Total number of responding teachers in each "general safety" category

	"General Safety" Categories							
	0	1	2	3	4	5	DNA	TOTALS
TOTALS	10	21	25	73	41	43	6	219

Figure 2



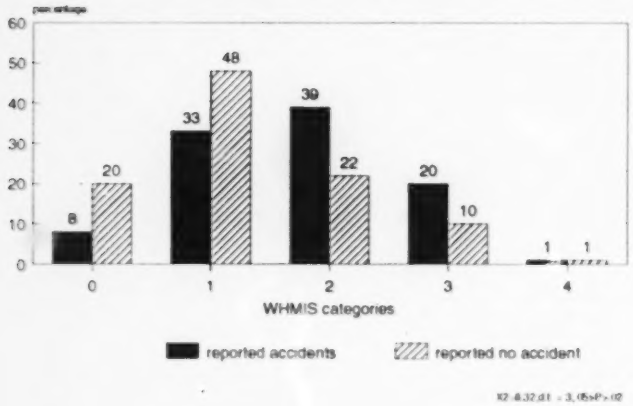
Record of Laboratory Accidents

Statistical tests indicate that there is a significant difference ($p<0.05$) among teachers in the various WHMIS categories in terms of the number who report having laboratory accidents in which one or more students are injured (Figure 3). Teachers who report no accidents have a higher percentage of their numbers in the two lowest WHMIS categories and a lower percentage in category 2 and category 3 than do teachers who report accidents.

The results of the teachers' reports on their experience with laboratory accidents that involved injury to students are consistent with increases in "general safety" scores. Of the 212 teachers who responded to this portion of the questionnaire, 135 (64 percent) report having no accidents. All but one of the 77 teachers who had accidents state that implementation of WHMIS regulations would not have been instrumental in preventing the accident. The types of injury reported include cuts from broken glass or burns resulting from touching hot objects or liquids. No incidents of ingestion or inhalation of toxic materials are reported nor are incidents of contact with corrosive or burn-producing chemicals. Where further information is given, teachers attribute the accidents to student carelessness and failure on the part of the students to observe the safety guidelines that had been given.

Figure 3

Distribution Among 10 Item WHMIS Categories of Teachers Reporting Accidents and no Accidents



These statements are corroborated by the frequencies of positive responses to the items concerning safety education. One hundred and seventy-five of the 191 teachers responding to an item concerning the presentation of safety instructions at the beginning of each student laboratory activity answered positively. One hundred and thirty-two responded positively to an item concerning the presentation of a safety unit at the beginning of the course and, of these, 11 represent an alternative to the safety discussions at the beginning of each activity. Thus, in total, 186 or 97 percent of the teachers either present safety instructions at the beginning of each activity and/or as a unit at the beginning of the course. The pertinent WHMIS regulations, namely the education of workers (students) regarding hazards on the job, had been implemented. The accidents occurred as a result of students ignoring the advice and warnings. There is only one case of litigation being brought against the school or teacher as a result of an accident, and this case was not successful for the plaintiff.

WHMIS Inspections

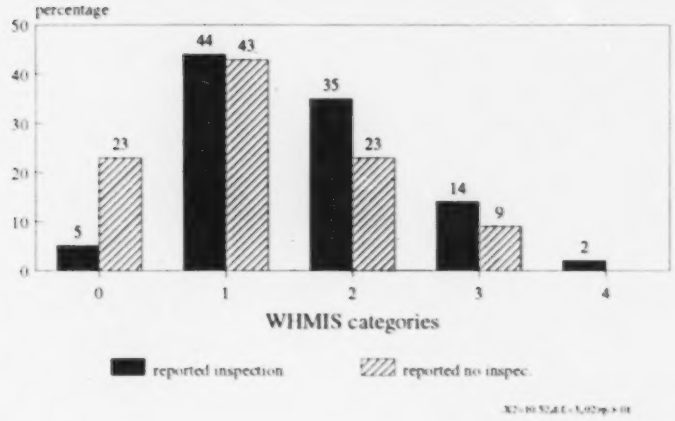
Some degree of classroom and/or laboratory inspection is reported by 55 percent of the teachers who responded to this question. There is a significant difference in the 10-item WHMIS categories between teachers reporting inspection and those reporting no inspection (Figure 4). Teachers who report no inspection have a higher percentage of their numbers in WHMIS category 0 (higher number of accidents; $X^2=10.52,3df,p<0.02$).

Percentage of Teachers Who Had Heard About the WHMIS Regulations

A greater percentage of rural teachers (23 percent) than urban teachers (10 percent) report not being aware of WHMIS regulations. However, this is not a statistically significant difference (Figure 1).

Figure 4

Distribution Among 10-Item WHMIS
Categories of Teachers Reporting
Inspections and No Inspections



Teachers' Knowledge and Implementation of WHMIS Regulations

Table 3. Number of respondents for 10-item WHMIS categories for rural and urban teachers

	WHMIS Categories						
Location of teachers	0	1	2	3	4	DNA*	TOTALS
Rural	24	54	27	7	0	16	128
Urban	9	37	25	16	2	2	91
Totals	33	91	52	23	2	18	219

* DNA - number of teachers who did not respond to this set of questions or responded incorrectly so that computation of a meaningful score and category was not possible.

Rural teachers more frequently score in the lowest two categories (0 and 1) of 10-item WHMIS implementation (70 percent of responding teachers) than do their Winnipeg counterparts (52 percent of teachers) (Table 3 and Figure 1). The reverse situation is true for the two highest WHMIS categories (3 and 4) where 6 percent of the rural sample and 20 percent of the urban sample attain these scores. Chi-square tests indicate significant differences in WHMIS knowledge and implementation categories for rural compared to urban teachers (X^2=12.86,3df,$p<0.01$). This significance persists when category 0 (X^2=12.86,3df,$p<0.01$) and category 3 & 4 (X^2=12.86,3df,$p<0.01$) are compared to the remainder of the sample. The significance disappears when category 1 and category 2 are compared to the remainder of the sample.

Teachers' Knowledge and Implementation of "General Safety" Items

There is no statistically significant rural-urban difference in the distribution of teachers among the 6-item general safety categories. Teachers in both rural and urban locations obtain better scores on these items than on the 10 WHMIS-specific items (Table 4 and Figure 2). Category 5, indicating complete implementation of these items, contains entries from both rural and urban sectors.

Table 4. 6-Item "general safety" categories for rural and urban teachers

	"General Safety" Categories							
Location of teachers	0	1	2	3	4	5	DNA	Totals
Rural	8	14	13	43	19	25	6	128
Urban	2	7	12	30	22	18	0	91
Totals	10	21	25	73	41	43	6	219
(X^2=5.74,d.f.=5, .50>p>.30)								

When the scores for WHMIS-specific items are combined with the scores for the "general safety" items, category 5 (full implementation) disappears and the frequencies in category 3 & 4 and category 2 decline. There still is no statistically significant difference between rural and urban teachers when the six "general safety" items are combined with the ten "WHMIS-specific" items to yield an overall score (X^2=7.01,d.f.=4,.20>p>.10).

Record of Laboratory Accidents and Inspections

There is no statistically significant difference between rural and urban teachers in terms of the percentage of teachers (31 percent rural and 44 percent urban) who have had laboratory accidents involving students (X^2=3.32,d.f.=1,.10>p>.05).

Similarly, no significant difference between rural and urban teachers is apparent for associations with laboratory inspections (X^2=1.60,d.f.=1,.30>p>.20). Thirty-eight percent of rural teachers and 46 percent of urban teachers report having some sort of inspection for WHMIS implementation.

WHMIS Knowledge and Implementation and School Student Population

Teachers' Knowledge and Implementation of WHMIS Regulations

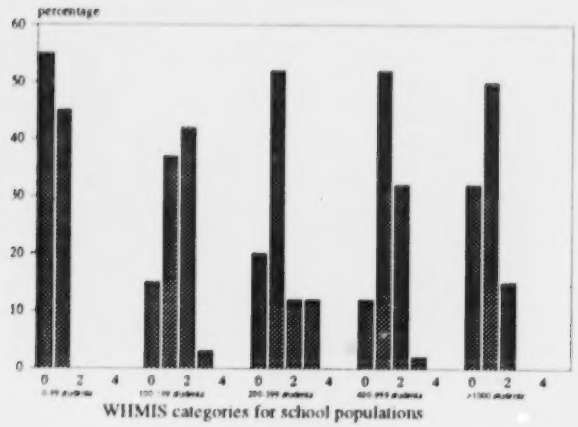
The 10-item WHMIS scores are analyzed on the basis of school student population (Table 5 and Figure 5). For the total sample, as well as each of the rural and urban subsamples, there is a trend to higher frequencies of teachers in the higher WHMIS categories as school population size increases. However, the increases in the number of teachers in categories 3 and 4 reverses and drops for teachers at schools of 400-999 students in all groups. In the urban schools, the number of teachers in categories 3 and 4 increases again at schools of 1000 or more students. In the rural sector, however, categories 3 and 4 have no representatives.

Table 5. 10-Item WHMIS categories by school student population

School population	WHMIS categories 0	1	2	3	4	DNA	Totals
Rural							
0-49	5	4	0	0	0	5	14
50-99	1	1	0	0	0	1	3
100-199	4	9	10	1	0	2	26
200-399	7	18	5	5	0	3	38
400-999	4	17	11	1	0	2	35
>1000	2	3	1	0	0	2	8
DNA re: pop	1	2	0	0	0	1	4
Rural totals	24	54	27	7	0	16	128
Urban							
100-199	1	1	0	0	0	0	2
200-399	2	7	2	4	1	0	16
400-999	5	21	16	6	1	2	51
>1000	1	6	7	6	0	0	20
DNA re: pop	0	2	0	0	0	0	2
Urban totals	9	37	25	16	2	2	91
Combined rural & urban							
0-49	5	4	0	0	0	5	14
50-99	1	1	0	0	0	1	3
100-199	5	10	10	1	0	2	28
200-399	9	25	7	9	1	3	54
400-999	9	38	27	7	1	4	86
>1000	3	9	8	6	0	2	28
DNA re: pop	1	4	0	0	0	1	6
Combined rural & urban totals	33	91	52	23	2	18	219

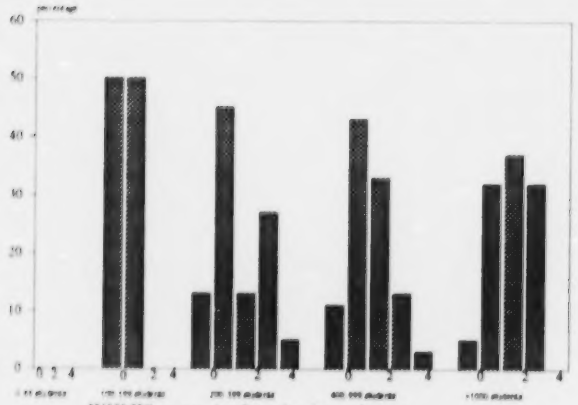
Figure 5

Rural Teachers



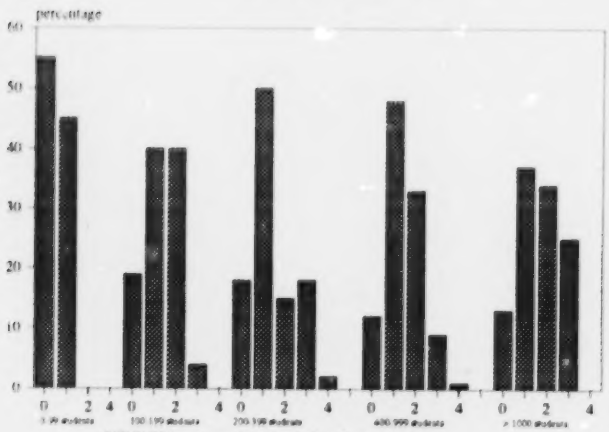
WHIMIS categories for school populations

Urban Teachers



WHIMIS categories for school populations

All Teachers



WHIMIS categories for school populations

WHMIS Knowledge and Implementation Among Teachers By Size Of School

Association analyses indicate significant differences between the distribution of WHMIS scores for teachers at schools with different student populations (X^2=18.82,9df,$p<0.05$). Since schools of less than 200 students are rural (with only 2 exceptions), tests are applied to sub-groups in an attempt to determine the significance of the WHMIS categories for teachers working at small schools. First, the scores of teachers at schools of less than 200 students are removed from the calculations (X^2=9.89,5df,$p>0.10$), and then the scores of teachers at schools of less than 100 students are removed (X^2=12.13,6df,$p>0.05$). In both cases there remain no statistically significant differences among the remaining population groups.

These results lead to a further consideration of the role played by scores originating from teachers at the smallest schools. A statistically significant difference remains when WHMIS categories of teachers from all schools of under 200 students are compared to categories of teachers from all schools of 200 or more (X^2=8.86,3df,$p<0.05$). As the group of teachers at schools of less than 200 is almost exclusively rural, tests are run within the rural sector alone. There is no significant difference in the distribution of WHMIS categories for teachers when scores of teachers at rural schools of less than 200 students are compared to those from rural schools of 200 or more students (X^2=3.26,3df,$p>0.05$). However, when rural teachers at schools of less than 100 students are compared to the remainder of the rural sample, there is a significant difference in WHMIS categories (X^2=4.05,1df,$p<0.05$).

Finally, when rural teachers at schools of 200 or more are compared to urban teachers at schools of 200 or more, there is a significant difference between their distribution in WHMIS categories (X^2=8.19,3df,$p<0.05$).

Associations Between WHMIS Knowledge and Implementation and Selected Teacher and School Characteristics

Teacher Characteristics and WHMIS Categories

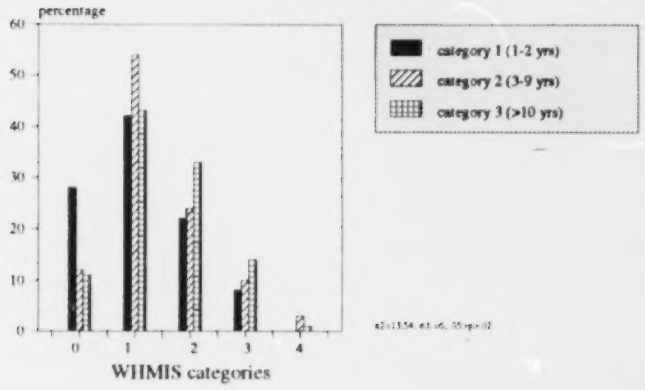
Variables that are related to the teachers' 10-item WHMIS knowledge and implementation categories include the following:

1) the degree to which teaching experience matches the grades and subjects currently being taught,
2) the grade levels taught,
3) grade 11-12 teachers compared to the rest of the sample,
4) a rural as opposed to urban location for grade 11-12 teachers,
5) academic background in university science credits, and
6) professional training in science methods and curriculum.

For the complete sample, teachers with less experience in the grades and subjects they currently are teaching also have a higher percentage of their members in the lower WHMIS categories (Figure 6). Teachers with only 1 or 2 years of experience in the area to which they currently are assigned had 28 percent of their group in category 0. In contrast, teachers with 3 to 9 years experience have only 13 percent in WHMIS category 0, and teachers with 10 or more years experience have only 12 percent of their group at the 0 level. In the higher WHMIS categories, the differences between "experience/match" categories lessens with 9 percent of the inexperienced teachers in WHMIS categories 3 & 4, compared to 12 percent of teachers with 3-9 years experience, and 14 percent of teachers with 10 or more years experience. While differences also are apparent in WHMIS categories 1 and 2, none are as striking as those for WHMIS category 0.

Figure 6

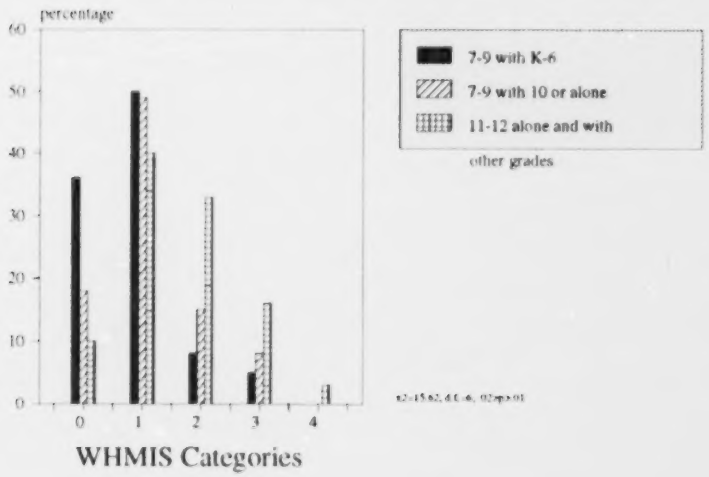
10-Item WHMIS Categories for Teachers
Associated with Experience Related to
Current Assignment



Teachers of higher grades have a higher percentage of their membership in the higher WHMIS knowledge and implementation categories (Figure 7). Only teachers of grades 11 and 12 are represented in WHMIS category 4. In category 3, the highest percentage is again provided by teachers of grades 11 and 12.

Figure 7

Percentages of Teachers of Different
Grades in Each WHMIS Category



The reverse is true for the lowest WHMIS categories. Teachers who are assigned both elementary grades and junior high have 80 percent of their membership in either category 0 or category 1.

WHMIS Categories for Grade 11 and 12 Teachers Compared to the Remainder of the Sample

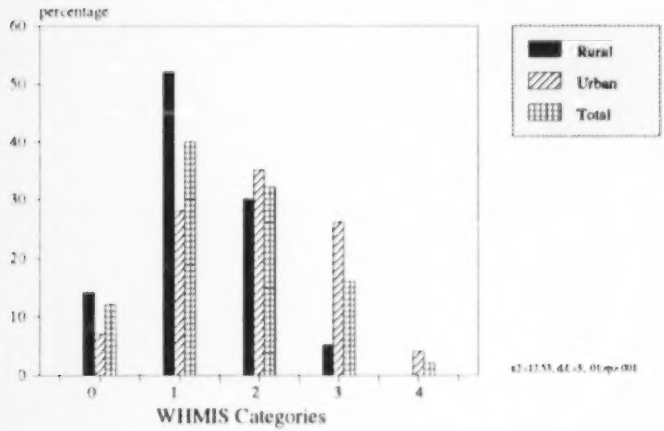
When all grade 11 and 12 teachers, both the specialists and those who taught lower grades as well as 11 and 12, are combined and compared to the remainder of the sample, a statistically significant difference remains in their distribution among WHMIS categories.

WHMIS Categories for Rural as Opposed to Urban Grade 11 and 12 Teachers

The grade 11 and 12 teachers are examined as a separate sub-sample for rural-urban differences in WHMIS knowledge and implementation. Again, there is a significant statistical difference (X^2=12.53, 3df, $p<0.01$). A higher percentage of rural grade 11 and 12 teachers are in the lower WHMIS categories of 0 and 1, a decrease is evident in rural teachers in categories 2 and 3, and no representation occurs in category 4 (Figure 8). Although the percentages are higher in the higher WHMIS categories than for the total rural sample, they are still low in comparison to the urban grade 11 and 12 teachers.

Figure 8

Percentage of Rural and Urban Grade
11-12 Teachers in Each WHMIS Category



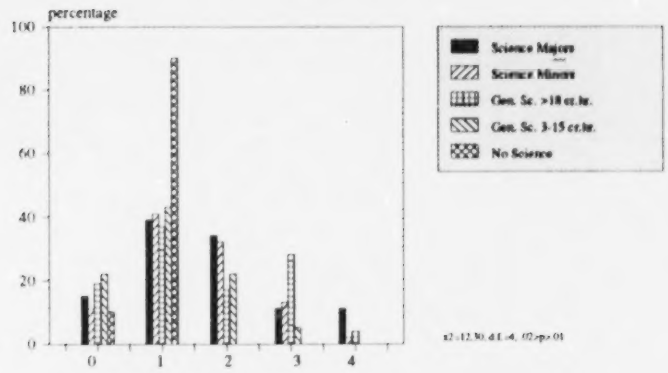
WHMIS Categories and Academic Background in University Science

Teachers without university science credits all are in WHMIS categories 0 and 1 (Figure 9). Similarly, 76 percent of teachers possessing from 3-15 credit hours of general science courses are in WHMIS categories 0 and 1. Just over half of teachers with 18 or more credit hours of general science courses, or science minors or majors are in these two categories.

Teachers with 18 or more general science credit hours have the highest percentage for WHMIS category 4. They are followed by those who have science minors. None of the other groups, including science majors are represented in category 4.

Figure 9

Percentages of Teachers with Varying Science Credits in Each 10-Item WHMIS Category



WHMIS Categories

The group of teachers with 18 or more general science credit hours also have the highest percentage of their group in category 3. Next highest are science minors, closely followed by science majors.

Overall, the academic background that produces the greatest percentage of high WHMIS implementers is 18 or more credit hours of general science, followed by science minors and majors. Those with little or no university science background score poorly in WHMIS knowledge and implementation. The association between science training and WHMIS knowledge and implementation is significant (X^2=12.30, 4df, $p<0.02$).

WHMIS Categories and Amount of Professional Training in Science Methods and/or Curriculum

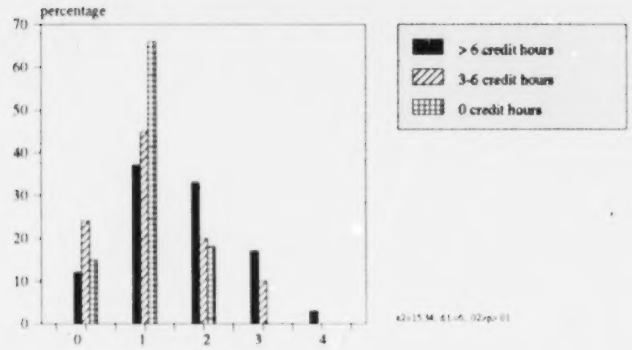
Teachers with more professional training in science methods and/or curriculum have higher percentages of their numbers in the higher WHMIS categories (Figure 10). Those with more than 6 credit hours of professional training in science methods or curriculum have the lowest percentages in the lowest WHMIS categories of 0 and 1, and the highest percentages in the three highest categories (2, 3 and 4). Generally, teachers with no professional training are in low WHMIS categories. With one exception in category 0, teachers with intermediate amounts of professional training (3-6 credit hours), have the highest percentage.

WHMIS Categories and School Student Population

The results of the first four tests that indicate significant differences in WHMIS categories among teachers at schools of different size student populations have been reported. There is a statistically significant difference among WHMIS categories of teachers at schools of different size student populations. Generally, teachers at larger schools have a higher percentage of their group in the higher WHMIS categories. This difference disappeared when teachers at schools of less than 200 students are deleted from calculations, and when teachers at schools of less than 100 are deleted.

Figure 10

Percentages of Teachers with Varying Professional Credits in Each WHMIS Category



WHMIS Categories

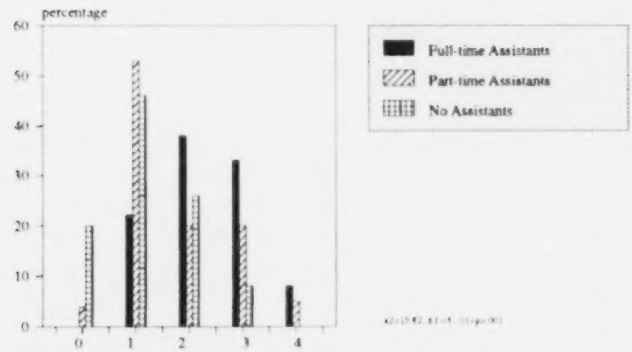
Within the rural sector, there is a significant difference in WHMIS scores of teachers at schools of less than 100 students and the remainder of the rural sample. The teachers at small schools have lower WHMIS scores. Urban teachers have higher WHMIS knowledge and implementation scores, even when only the larger schools are considered.

WHMIS Categories and Access to Laboratory Assistants

Teachers with full-time or part-time laboratory assistants obtain higher WHMIS scores significantly more often than do teachers without assistants ($X^2=15.82$, 3df, $p<0.01$). The numbers involved make it necessary to combine teachers with full-time assistants and teachers with part-time assistants for some statistical analyses. These two sub-samples, however, are presented separately in Figure 11.

Figure 11

Percentages of Teachers with Access to Full-time, Part-time or No Assistants in Each WHMIS Category



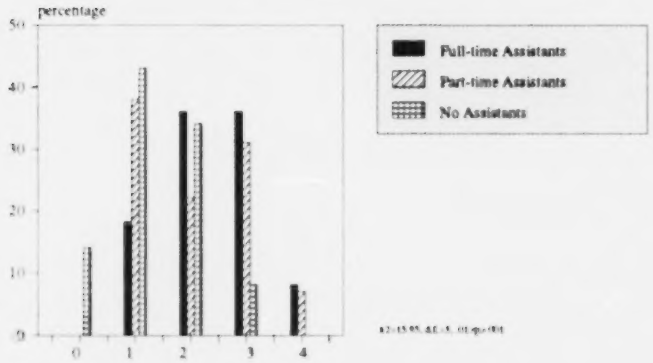
WHMIS Categories

Only teachers with assistants occur in WHMIS category 4. Teachers with full-time assistants have the highest percentages of their group in categories 2 and 3. The total percentages for the top three categories combined are 78 percent for teachers with full-time assistants, 44 percent for those with part-time assistants and 34 percent for those with no assistants. No teachers with full-time assistants are in category 0. By contrast, 66 percent of the teachers without access to assistants are in categories 0 and 1.

The overall association evident in the complete sample (Figure 11) remains when only grade 11 and 12 teachers are analyzed (Figure 12). Change consists of a slight increase in the percentages of teachers with part-time and full-time assistants in categories 3 and 4, a decrease in the percentage of teachers with part-time assistants in category 1 and a complete disappearance of teachers with part-time assistants from category 0. This leaves only teachers without assistants in category 0 for grades 11 and 12. The association between assistance and WHMIS knowledge and implementation for grade 11 and 12 teachers is significant (X^2=15.95, 3df, $p<0.01$).

Figure 12

Percentages of Grade 11-12 Teachers with Access to Full-time, Part-time or No Assistants in Each WHMIS Category



WHMIS Categories

Differences in Selected Teacher and School Characteristics for Rural-Urban Locations and Different School Population Sizes

The first portion of this section is restricted to an examination of those characteristics found to be associated significantly with the teachers' WHMIS knowledge and implementation categories. This is followed by a summary of all teacher and school characteristics surveyed in order to present general rural-urban profiles.

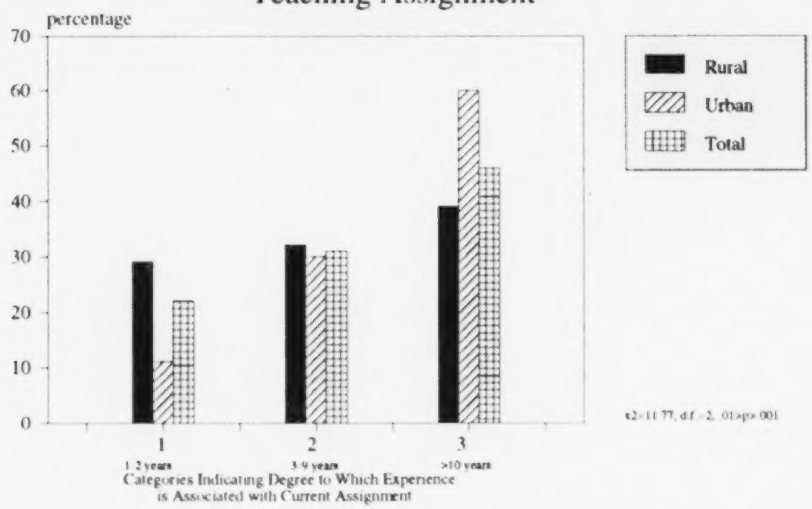
The only teacher characteristics that are related to WHMIS categories and also to rural or urban location are the degree to which the teaching assignment matches teaching experience, and the amount of professional training in science methods and curriculum. No significant associations occur for the following characteristics: 1) current teaching matching experience by size of school, 2) grade levels taught last two years, 3) grade 11-12 teachers as a proportion of total, and 4) academic background in science credits.

Degree to Which Experience Matches the Grades and Subjects Currently Taught

Both rural and urban subsamples have the largest portion of teachers in category 3, representing 10 or more years of experience teaching those grades and subjects currently being taught (Figure 13). The percentage of urban teachers in this category, however, is much higher than that for rural teachers. Similarly, the percentage of urban teachers in category 1, which represents only 1 or 2 years of experience in the grades and subjects currently being taught, is considerably lower than that for rural teachers. The percentage of teachers in category 2 (3 to 9 years experience) is about the same for both urban and rural sectors.

Figure 13

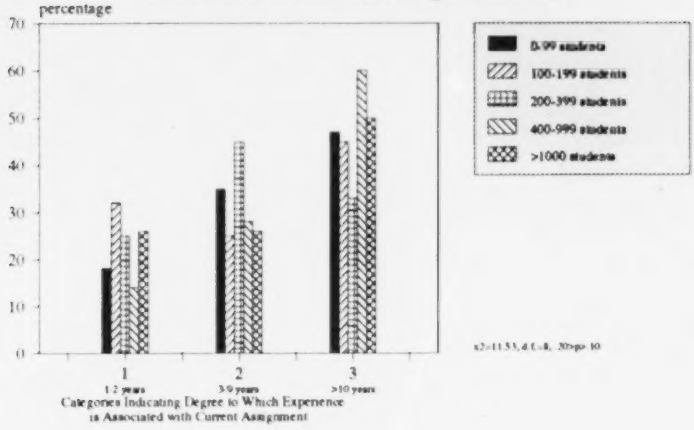
Percentage of Rural and Urban Teachers in Each Category Indicating Degree to Which Experience Matches Current Teaching Assignment



Statistical analysis of the association between teaching experience and current teaching assignment for different sizes of student populations does not show a significant difference ($X^2=11.53$, 8df, $p>0.05$). Schools of all student population sizes have most of their teachers in category 3 which represents the most experience in the grades and subjects taught for the past two years (Figure 14).

Figure 14

Percentage of Teachers from Different School Population Sizes in each Category Indicating Degree to Which Experience Matches Current Teaching Assistant



Professional Training

Nearly the same percentages of rural and urban teachers report having no professional training in science methods or curriculum (Table 6). The difference between rural and urban subsamples occurs in the higher percentage of urban teachers reporting more extensive professional training.

Table 6. Professional training in science methods and curriculum for rural and urban teachers

Location	Teachers with 0 credit hours	Teachers with 3-6 credit hours	Teachers with >6 credit hours
Rural	18%	37%	45%
Urban	19%	20%	61%
(X^2=6.58, d.f. = 2, .05>p>.02)			

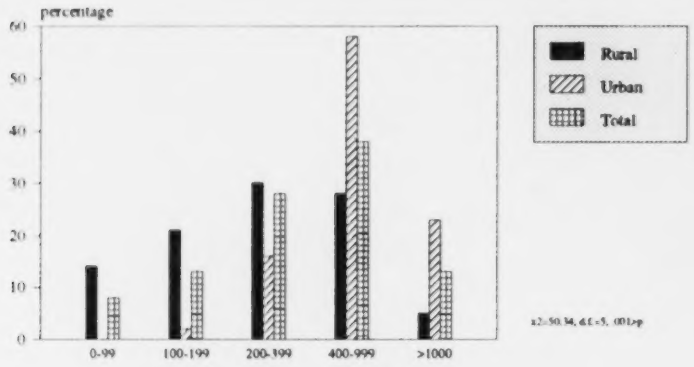
Significant differences between rural and urban schools exist in both size of school population and the availability of laboratory assistants.

Size of School Student Population

Rural schools generally are smaller than urban schools (Figure 15). Few urban teachers work at schools of less than 200 students. However, even when schools of less than 200 students are eliminated from consideration, there remains a significant statistical difference between urban and rural school student populations (X^2=16.98, d.f.=2, $p<0.05$). The proportion of teachers who work at schools with 400 to 999 students is much greater for urban than for rural schools. This is true also for teachers at schools of more than 1000 students. The association between the variables is significant (X^2=50.34, 5df, $p<0.01$).

Figure 15

Percentage of Rural and Urban Teachers
Working at Schools of Different Student
Populations



School Student Population

Access to Laboratory Assistants

The other school variable that shows a significant rural-urban difference is the availability of laboratory assistants (X^2=47.55, d.f.= 2, $p<0.01$). Nearly 100 percent of all assistance is reported by urban teachers. Only 3 out of 127 rural teachers report access to part-time assistants, compared to 36 out of 91 urban teachers who had either full or part-time assistants.

The grade taught is not significantly associated with availability of laboratory assistants for the urban sub-sample (X^2=2.43, d.f. =1, $p>0.05$). However, a larger percentage of urban grade 11-12 teachers (49 percent) have assistants than do urban teachers of other grades (31 percent).

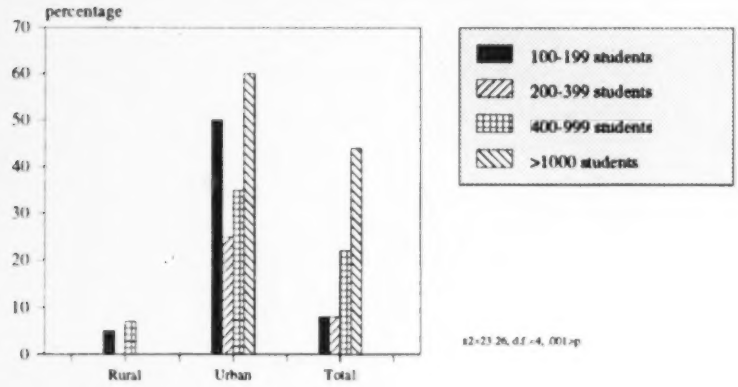
An examination of the association between total school population and the availability of laboratory assistants (Figure 16) reveals a trend toward increasing percentages of teachers with access to laboratory assistants as the school population increases. With student population of 1000 or more, 60 percent of the urban science teachers have access to assistants.

Rural-Urban Profiles Resulting From an Examination of Teacher and School Characteristics

Little difference is evident between the rural and urban subsamples in terms of proportions by sex, average age and average number of years of teaching experience (Table 7). Association analysis reveals no significant difference in these three characteristics.

Figure 16

Percentage of Teachers Working in
Schools of Different Student Populations
Having Access to a Laboratory Assistant



School Student Population

Table 7. Rural and urban teacher profiles

Teacher characteristic	Rural		Urban		Combined	
	Male	Female	Male	Female	Male	Female
Number	99	28	72	19	171	47
Percent	78	22	79	21	78	22
Average age (yrs)	42	36	45	39	44	37
Average teaching experience (yrs)	19	11	21	12	20	11

The only significant differences between rural and urban teachers in terms of teacher characteristics occur in the categories representing the degree to which teaching experience matches the grades and subjects which currently are being taught, and in the amount of professional training. Because these also are related to the teachers' WHMIS knowledge and implementation categories, the results were reported in the previous section.

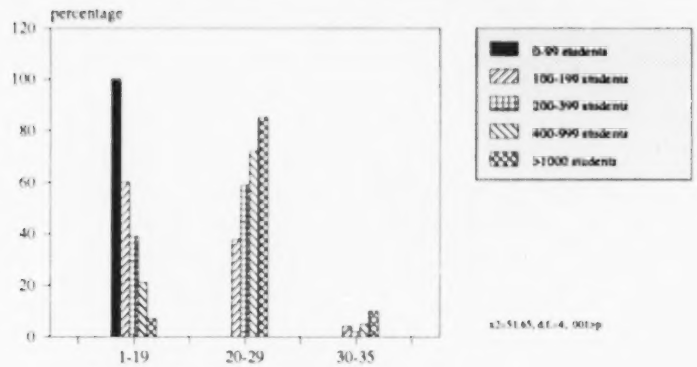
Rural and Urban School Characteristics

In addition to the significant associations between size of student population and availability of laboratory assistants and rural or urban locations, there is a rural-urban difference in class size (X^2=16.10, 1df, $p<0.01$). Rural classes are smaller, with 14 rural teachers reporting average class sizes of less than 10 students. No urban teachers report average class sizes this small. Average class sizes of less than 20 students account for 48 percent of the rural teachers and only 20 percent of the urban teachers.

When the variable of average class size is compared to the overall student population of the school, schools of lower total student population have larger percentages of teachers reporting lower average class sizes (Figure 17). All teachers at schools of less than 100 students report average classes of less than 20 students. By contrast, only 7 percent of teachers at schools of more than 1000 students report class sizes of less than 20 students. This association is significant (X^2=51.65, 4 df, $p<0.01$).

Figure 17

Average Number of Students Per Class
For Teachers Working at Schools of
Different Student Population Sizes



The majority of teachers with class sizes in excess of 20 students are concentrated in schools with student populations of more than 200. When the teachers at schools of less than 100 students are deleted from the study, however, a statistically significant difference remains among the remaining school population sizes (X^2=9.08, d.f. =1, .01>p>.001).

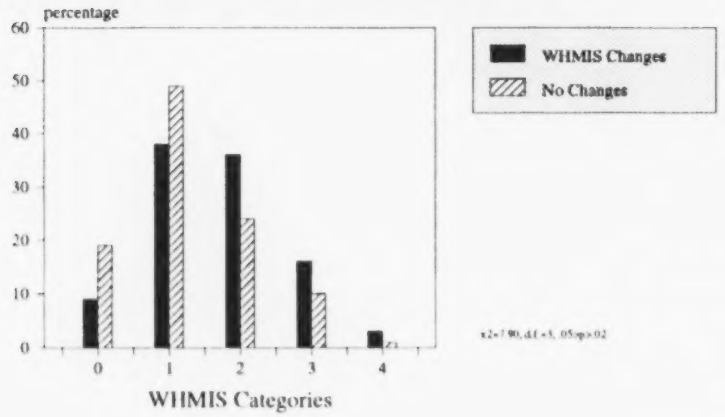
Relationship Between WHMIS Knowledge and Implementation Categories and Reported WHMIS-Related Changes in Student Laboratory Activity

There is a statistically significant difference in the frequency of teachers appearing in the various WHMIS categories for teachers who report WHMIS-related changes to their laboratory work as opposed to teachers who report no such changes. There are more teachers in the higher WHMIS categories among those who report making changes to comply with WHMIS regulations (Figure 18).

Fifty-seven of the 219 teachers answering the questionnaire (26 percent), report making deletions or significant substitutions to student laboratory activities as a result of WHMIS regulations. Of the 57 teachers, 19 (33 percent) think that these changes are detrimental to their students' learning. Seven teachers specify biological hazards such as saliva and blood, as the cause of the WHMIS-induced changes, 32 cite chemical hazards with the most frequently-mentioned chemicals being benzene, organic chemicals and solvents in general, carbon tetrachloride, ether and mercury. Two teachers attribute the deletion of burners for student use to WHMIS, 2 claim the complete avoidance of students doing lab work, and 7 fail to specify the nature of the deletions of changes.

Figure 18

Percentage of Teachers Who Report WHMIS-Related Lab Changes and Percentage Who Report No Changes in Each WHMIS Category

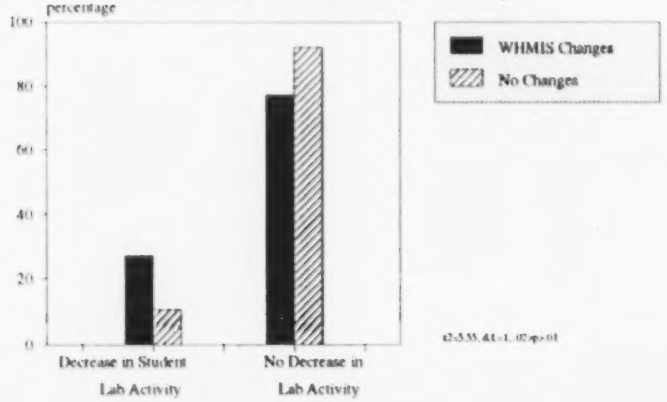


Association Between WHMIS-related Changes in Student Laboratory Activity and Reported Decreases in Student Laboratory Activity

There also is a noticeable difference in the number of teachers reporting decreases in the overall amount of student laboratory activity and the number reporting WHMIS-related changes in laboratory work. Teachers who made WHMIS-related changes also are more likely to have experienced an overall decrease in student laboratory activity than teachers who report not having made WHMIS-related changes.

Figure 19

Percentage of Teachers Who Report WHMIS-Related Lab Changes and Percentage Who Report No Changes Who Also Report Decreases in Student Lab Activity



Differences in Student Laboratory Activity in Rural and Urban Locations, and in Schools with Different Size Student Populations

Teachers Reporting Overall Decreases in Student Laboratory Activity Over the Past Five Years

There is a significant difference in the number of rural as opposed to urban teachers who report decreased student laboratory activity. Urban teachers are more likely to report such decreases (X^2=4.31, d.f. =1, .05>p>.02). Difference in the size of the school student population, however, is not significant in the frequency of these reports (X^2=.64, d.f. =3, .90>p>.80).

Estimated Percentage of Classroom Time Devoted to Student Laboratory Activities: Rural-Urban Comparisons

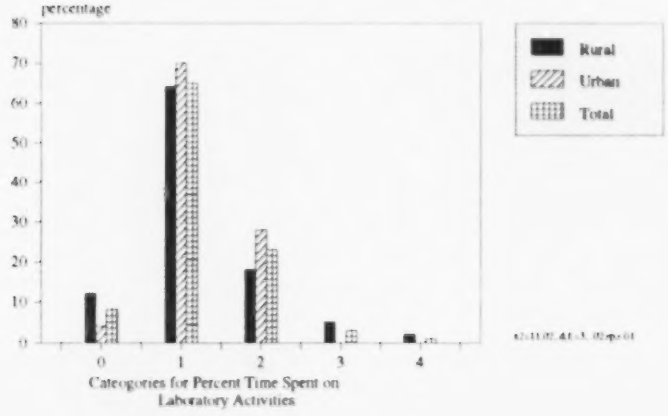
The most noticeable feature of rural-urban differences in student laboratory time is the complete absence of urban teachers in either category 3 or 4, and a large number of rural teachers reporting no student laboratory activity (Table 8 and Figure 20). There also is a higher percentage of urban teachers in category 2.

Table 8. Numbers of teachers in the categories for percentage of time devoted to student laboratory activity

Location	Category: % time devoted to student labs						
	0	1	2	3	4	DNA	Totals
Rural	13	70	21	6	2	16	128
Urban	3	55	22	0	0	11	91
Totals	16	125	43	6	2	27	219
(X^2=11.02, d.f. =3, .02>p>.01)							

Figure 20

Percentages of Rural and Urban Teachers in Each Category for Percentage Time Spent on Student Laboratory Activities



There is a statistically significant difference in the distribution of teachers among percentage time student laboratory activity categories between rural and urban locations (X^2=11.02, 3df, $p<0.02$). Also significant is the distribution of teachers in the two highest laboratory categories combined (3 and 4), compared to the three lowest combined (0, 1 and 2). However, there are no statistically significant differences among the three lowest categories themselves, nor for the rearranged comparison when category 2 is grouped with categories 3 and four instead of categories 0 and 1.

Estimated Percentage of Classroom Time Devoted to Student Laboratory Activities: Comparisons for Schools with Different Size Student Populations

Teachers at schools of 1000 or more students are absent from categories 3 and 4 of student lab time (Figure 21). The second noticeable feature is the high number of teachers in schools of less than 100 students reporting no student laboratory activity. This is limited to rural locations only, as no urban teachers report working at schools this small. With the exception of schools with less than 100 students, highest percentages of teachers at schools of all sizes are in category 1, with category 2 as next highest.

A significant statistical difference occurs when the frequencies of teachers in the categories for percentage time spent on student laboratory activity is compared with the student population of the school. When the eight rural teachers in categories 3 and 4 combined are eliminated from consideration, the difference between the remaining three categories remains significant. Removal of teachers reporting no student laboratory activity for comparisons of frequencies in categories 1 and 2, and then frequencies in categories 1, 2 and the combined 3 and 4, result in no significant differences among the remaining groups.

When statistical tests are completed with the scores of teachers at schools of less than 200 students removed, there no longer is a significant difference among population groupings in terms of laboratory time. This lack of significant difference persists as teachers at schools of less than 100, and finally teachers at schools of less than 50 students are dropped from consideration. That is, there is no significant difference between student population groups unless teachers at schools of less than 50 students are included in the statistics. On the other hand, when teachers at schools of 1000 or more students are deleted from consideration, there is still a statistically significant difference among the remaining student population groups.

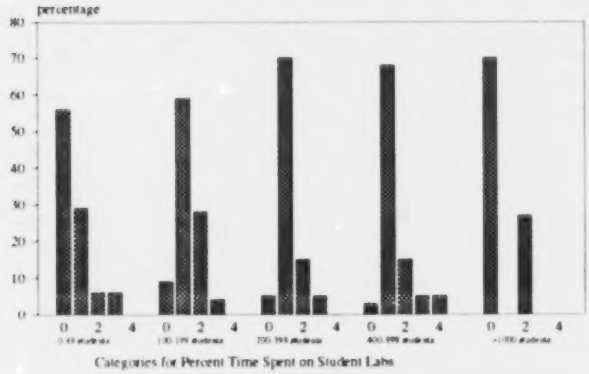
Number of Student Laboratory Activities as a Percentage of Those Recommended by Grades 11 and 12 Curriculum Guides: Rural-Urban Comparisons and Student Population Comparison

Categories created by a comparison of the number of student labs reported by grade 11 and 12 teachers as a proportion of the number recommended for the specific subject in the provincial curriculum guide are used for rural-urban comparisons (Figure 22). No statistically significant differences occur either between rural and urban teachers or among teachers from schools of varying student populations.

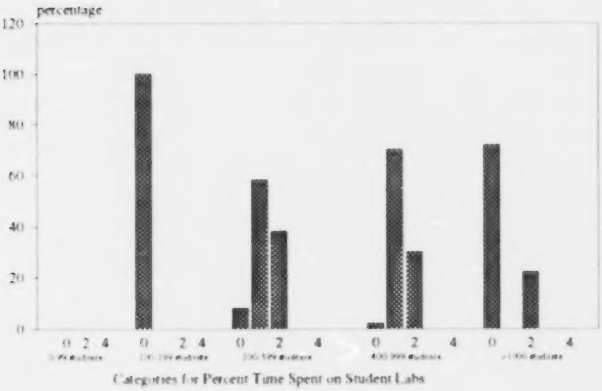
At these grade levels there is no incidence of 0 student laboratories. A high percentage of teachers (44 percent of rural teachers and 48 percent of urban teachers), are implementing the total number or more than the total number of activities recommended in the curriculum guides. Seventy percent of all grade 11 and 12 teachers are using 75 percent or more of the recommended number of labs and 87 percent are implementing 50 percent or more.

Figure 21

Percentages of Rural Teachers From
Schools of Different Size Student
Populations in Each Lab Time Category



Percentages of Urban Teachers From
Schools of Different Size Student
Populations in Each Lab Time Category



Percentages of Total Teachers From
Schools of Different Size Student
Populations in Each Lab Time Category

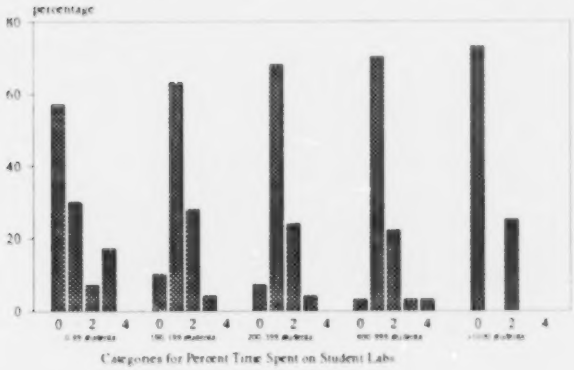
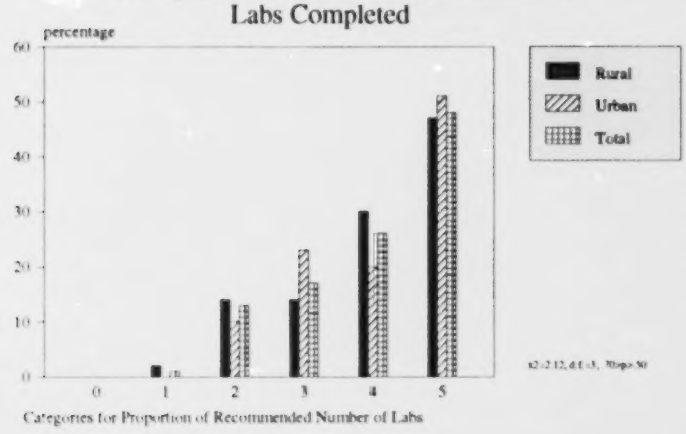


Figure 22

Percentages of Grade 11-12 Rural and 11-12 Urban Teachers in Each Category for Proportion of Recommended Number of Labs Completed



Teachers' Reports of Changes in Laboratory Activities as a Result of the Implementation of WHMIS Regulations and Teachers' Reports of Changes in the Overall Amounts of Student Laboratory Activities over the Past 5 Years: Rural-Urban Comparisons

Statistical tests were completed on these variables and school location. In spite of the significance of the association between WHMIS categories and the reports of WHMIS-related laboratory changes, and of the association between reports of WHMIS-related changes and reports of an overall decrease in student laboratory activity, there is a significant rural-urban difference only in the frequency with which teachers report overall decreases in the amount of student laboratory activities.

DISCUSSION AND ANALYSIS

Knowledge and Implementation of WHMIS Regulations and General Safety Items

A count of responses to the 16 items relating to knowledge and implementation of WHMIS safety regulations reveals that no teacher scores 100 percent. In addition, many teachers who claim no knowledge of WHMIS, nevertheless, obtain non-0 scores. When the items which these teachers answer correctly are examined more closely, it is apparent that their score is, in fact, produced by items that are designated "general safety". Some of these questions test laboratory safety procedures that pre-date WHMIS. These items are not useful in discriminating between teachers specifically implementing WHMIS and those who are not. It is concluded, therefore, that the separation of the items into the set of 10 specifically WHMIS-related items and the set of 6 "general safety" items is a useful distinction. The 10-item score, which provides the truest indication of knowledge and implementation of the actual WHMIS document, is used in investigating associations between WHMIS implementation and other variables.

The overall low scores on the 10 items specific to knowledge and implementation of WHMIS regulations occur in spite of the fact that 89 percent of the teachers surveyed claim to have heard about the WHMIS regulations. This indicates that either few teachers participate in any detailed inservice training sessions about the regulations or that sessions held are not successful in achieving the desired effect. A detailed investigation into the time spent on pre-implementation training and the type of training was not carried out as part of this study. Therefore, Slaugh's 1984 study indicating that successful implementation of a curriculum innovation requires more than what is usually considered an adequate amount of inservice training is neither confirmed nor contradicted.

The fact that teachers score well on items that relate to the science laboratory safety measures generally advocated in teacher training, indicates that the teachers are not careless. They obviously take measures to ensure their students' safety. This is further confirmed by the low incidence of serious accidents involving students. It is reasonable to assume that teachers, aware of their own safety records, are satisfied that the measures they already are taking provide adequate safety for their students, and that the introduction of additional WHMIS measures is unnecessary. Literature on curriculum implementation emphasizes the importance of the teacher's dissatisfaction with the existing situation as motivation for change (Brosnan 1994; Rafferty 1992' & Pratt 1980). It is possible, then, that the poor knowledge and implementation of WHMIS regulations results from a lack of perceived need by Manitoba science teachers for laboratory safety measures beyond what they have been using.

Record of Laboratory Accidents

In spite of the low overall knowledge and implementation of WHMIS regulations, the teachers' reports of student involvement in laboratory accidents indicates that those safety measures that are in place both control the number of accidents and prevent the occurrence of accidents of a serious nature. The majority of the teachers who responded to these questions indicate that they have never had a laboratory accident resulting in student injury. The minority who report accidents involving injury to students indicate that adequate safety instruction is given and the injuries are the result of student negligence in heeding warnings. Only one of the teachers reporting accidents thought that the implementation of WHMIS regulations might have prevented an accident. This suggests that junior and senior high school science teachers are making the student laboratories of Manitoba schools as safe as may reasonably be expected. There appears to be no current situation regarding student laboratory accidents in Manitoba junior and senior high schools that would necessitate making immediate changes in school laboratory safety practices. Improved knowledge and implementation of WHMIS regulations may be desirable for other reasons, but it is not likely to be perceived by the teachers as necessary to prevent student injury.

There is a statistically significant difference in the WHMIS categories of teachers reporting laboratory accidents involving students and teachers reporting no such accidents. A higher percentage of teachers who do report student accidents also score higher in terms of WHMIS knowledge and implementation. It seems unlikely that implementation of WHMIS could itself lead to a higher accident rate. The experience of having had a student injured in class, however, might result in the teacher being more acutely aware of laboratory safety practices and more open to changes in that area of curriculum.

One might be inclined to attribute this association to the possibility of both the occurrence of accidents and high WHMIS categories being associated with more of student laboratory activity. However, results suggest that the amount of student laboratory activity is not associated significantly with WHMIS categories.

Another possible explanation of the association might be that, while there is no difference in the amount of laboratory activity, there might be an important difference in the type of experiments conducted by the teachers who are in higher WHMIS categories and who report accidents. It is possible that the types of laboratory activities upon which the WHMIS regulations have an obvious bearing also are the activities in which accidents are more likely to occur.

WHMIS Inspections

There also is a statistically significant association between the teacher's WHMIS category and whether or not the teacher has a classroom/laboratory inspection for implementation of any facets of WHMIS regulations. Reports of inspection accompany higher WHMIS scores. This suggests that outside pressure in the form of inspections may create motivation to implement.

WHMIS and General Safety Knowledge/Implementation: Rural-Urban Comparisons

A statistically significant difference exists between rural and urban teachers in regard to the 10-item, WHMIS-specific categories. No significant differences are found between rural and urban teachers in regard to the 6-item "general safety" categories or the 16-item combined categories. That is, the difference occurs in the knowledge and implementation of a set of new regulations and not in the basic safety procedures that are part of standard student laboratory routine.

The fact that rural teachers score as well as urban teachers on the "general safety" items and the combined categories suggests that all Manitoba science teachers are implementing safety measures, although not necessarily WHMIS-specific ones, in their laboratories. This confirms that the higher frequencies of rural teachers in the lower 10-item WHMIS categories is not a result of either lack of concern for safety on the part of rural teachers or lack of ability to ensure student safety. In addition, there is no significant difference between rural and urban teachers in the number reporting student injuries. As reports of accidents are low for both sectors, safety measures currently in place appear to be effective.

Learning about and implementing new classroom or laboratory procedures requires the teacher's time and effort, convenient access to the means of such learning and the conviction that making the necessary effort is worth while. The higher frequencies with which urban teachers appear in the higher 10-item WHMIS-specific categories suggest that they are in a better position than their rural counterparts to incorporate the new procedures into their classroom and laboratory routines. The significance of the larger number of low-scoring rural teachers is considered in the following section on student population.

Because the difference in the proportion of rural as opposed to urban teachers who have not heard about the WHMIS regulations is not statistically significant, a lack of access to information regarding the existence of the regulations likely does not contribute substantially to the rural-urban difference in scores.

Also, the lack of any significant difference between rural and urban teachers regarding whether or not they have any sort of inspection, means that the difference in rural-urban implementation cannot be attributed to a lack of inspection in rural schools.

WHMIS Knowledge and Implementation and School Student Population

Low WHMIS scores are concentrated in schools of less than 100 pupils, all of which occur in the rural sub-sample. When teachers in schools of 100-199 students are included, the percentage in the two lowest categories drops from 100 percent to 70 percent but still does not compare well with the remainder of the sample (i.e. those teachers working in schools of more than 200 students, who had a lower, though still high (58 percent) percentage in categories 0 and 1 combined). Teachers at schools with 100 to 199 students, while showing a decrease in the frequency of very low scores and an improvement in the frequencies of higher categories, still are low overall when compared to the sub-sample of schools of more than 200. Again nearly all taught in rural locations. This suggests that, within the overall problem of low WHMIS implementation, teachers in small schools experience greater than average difficulties.

Statistical significance of differences by student population is lost when first the scores of teachers at schools of less than 200 students, and then those at schools of less than 100 students are removed from consideration. This suggests that differences related to school size are dependent upon inclusion of teachers from smaller schools.

To examine the influence of teachers from schools serving between 100 and 199 students compared to those with fewer than 100 students, frequency differences of teachers at various school sizes within the rural sector itself are examined. There is no significant difference in WHMIS categories between teachers at schools of less than 200 and those at schools of 200 or more students. However, there is a statistically significant difference when teachers at schools of less than 100 students are compared with the rest of the rural sample. This implies that the greatest source of difference within the rural sub-sample is the scores of teachers at schools of less than 100 students. This portion of the statistical study should be interpreted cautiously as the low number of responses from teachers at schools of less than 100 students makes it necessary to collapse the data to a comparison of the numbers in categories 0 and 1 combined with the numbers in categories 2 and 3 and 4 combined. Descriptive data, however, support the notion of the importance of scores from schools of 100 or fewer students, as no teacher at a small school is in a WHMIS category higher than 1.

When teachers' scores from the urban sector are reintroduced to the statistics, the difference between the distribution of scores of teachers at schools of less than 200 students and those at schools of 200 or more is significant again. This reflects the difference created by reintroducing the urban teachers with categories of 3 and 4. Also, when only scores from schools of 200 or more pupils are compared, there remains a rural-urban difference, just as there was when all scores are considered. These results indicate that school size, while influential, is not the only factor contributing to the rural-urban difference in WHMIS implementation. Since the rural-urban difference persists when a rural-rural difference does not (for schools of more than 200), there is a component other than student population leading to higher WHMIS scores. This component is either unique to or significantly more prevalent in the urban schools.

Differences in 10-item WHMIS Categories for Selected Teacher and School Characteristics

Teacher Characteristics

Teacher characteristics that are related to the WHMIS categories are linked with the teachers' academic and professional preparation. Teachers with more credits in academic and professional university courses, and those with more teaching experience in the specific subjects and grades they currently are assigned to teach, have higher WHMIS knowledge and implementation scores. Possession of any of these characteristics likely would facilitate preparation and delivery of daily class lessons, thereby allowing more time for learning about WHMIS regulations and integrating the additional material into their routines. As is pointed out in the review of related literature, sufficient time is an important component of successful implementation (Rafferty, 1992; Fullan and Stiegelbauer, 1991; Slaugh, 1984). The characteristics of sex, age, total teaching experience and length of time at the school where currently employed, which are not directly related to the teachers' preparation for specific, current assignments, are not statistically associated with WHMIS categories.

Degree to which Teaching Experience Matches the Grades and Subjects Currently Being Taught

A higher degree of matching of past experience with current teaching areas is associated with higher WHMIS categories. This result contradicts the findings that experience is an inhibitor of change (McLaughlin and Marsh, 1978). An explanation for the apparently conflicting results might lie in the fact that major efforts to inform teachers about the details of the regulations might well have been concentrated in the time period immediately prior to and/or following the actual introduction of the legislation. Because this occurred only five to six years ago, teachers with only 1 or 2 years of experience in teaching science courses may have missed initial distribution of information and inservices.

Grades and Subjects Taught

There is a statistically significant association between teachers of higher grades and scores in higher WHMIS categories. This suggests that student laboratory work in higher grades increases the teacher's need to become informed about and to implement the regulations. The examination of WHMIS categories and reports of accidents involving injury to students also suggests that the type of laboratory activity might be significant, even if the amount of student laboratory activity is not. With this possibility in mind, WHMIS categories of grade 11-12 chemistry teachers are compared with WHMIS categories of other grade 11-12 teachers. This investigation, however, produced no statistically significant differences. Nor are there any significant differences in WHMIS categories between grade 11-12 teachers who specialize in one subject and those who taught several. Therefore, while the grade level itself appears to make a difference, the subject matter taught and the number of subjects taught does not.

Even though a greater number of university science credit hours is associated positively with higher WHMIS scores, teachers with a variety of subject matter actually score higher than those whose education is more specialized. Furthermore, there is no statistical association between WHMIS knowledge and implementation and the degree to which teachers' academic backgrounds match their current teaching assignments. One may speculate that an important factor at work in producing higher WHMIS categories for the grade 11-12 teachers is not subject specialization but, rather, a greater familiarity with laboratory work in general.

In addition, there remains a statistically significant difference between rural and urban 10-item WHMIS categories among the grade 11-12 sub-sample. This indicates the existence of a factor peculiar to the urban grade 11-12 teachers that increases their frequency in the higher WHMIS categories.

Academic Background in University Science

In general, the more credit hours a teacher obtains in university science, the higher their position in the WHMIS knowledge and implementation categories. This trend, however, is not dependent upon a high degree of specialization. In fact, the highest frequency of high WHMIS categories appears among teachers who have 18 or more credit hours (6 or more single semester courses) in a general science background. The next highest frequencies of high WHMIS categories occurs in science minors and science majors. Teachers with no university science training at all fare poorly with none achieving a WHMIS category above 1.

Rafferty (1992) and Toch (1991) conclude that adequate general subject matter preparation is an important teacher characteristic for implementation of new programs. In the case of WHMIS regulations, which do not constitute an entirely new program, subject matter specialization is not important to giving the teacher the ability to implement changes as long as the teacher has sufficient university science courses to gain a general facility in laboratory use. Such facility likely would produce more teacher confidence and thus reduce resistance to implementing additional regulations. Such training also could have the effect of making the teacher more aware of activities that would pose the greatest hazards to students.

Professional Training in Science Methods and Curriculum

The amount of professional training also is associated significantly with teachers' positioning in WHMIS categories. This suggests that increased academic background, whether in subject matter or in professional areas, may facilitate the implementation of changes. Again, the possibility of increased background contact with ideas and methods appears instrumental in creating a climate of confidence and willingness to make changes.

Teachers with professional course work also may have encountered information on the content and means of implementing WHMIS regulations. If so, their improved WHMIS scores undoubtedly are related to their specific knowledge of the material to be implemented. Slaugh (1984) and Smorodin (1984) both stress the importance of such preparation for change.

School Characteristics

Size of Student Population

The fact that teachers' WHMIS categories are low for teachers at small schools, and that scores increase with increasing school size has been discussed.

Access to Laboratory Assistants

The availability of laboratory assistants also is associated with WHMIS categories for teachers. A question arises regarding the role played by an assistant in increasing the classroom teacher's knowledge and implementation of WHMIS. The first and most obvious possibility is that access to an assistant provides the teacher with more time to spend on acquiring knowledge about and deciding upon implementation strategies for the new material. With increasing demands being made upon teachers' time, it may be difficult to accommodate more demands without additional personnel to assume some of the responsibilities. This supposition is supported by the work of Rafferty (1992), Fullan and Stiegelbauer(1991) and Smorodin (1984), all of whom found additional planning time conducive to implementation of a new program.

Another possibility is that a laboratory assistant provides resources beyond that of making time available for implementation. If the assistant possesses a background in laboratory technique and, as part of the profession, makes a point of being informed about new techniques and requirements, they can act as a permanent classroom curriculum coordinator for the implementation of WHMIS regulations. Researchers in curriculum implementation discuss the importance of human assistance, whether in the form of cooperating teachers, curriculum co-ordinators, expert advisors, or sympathetic administrators, to teachers engaged in implementation (Rafferty, 1992; Fullan,1991; James and Hall, 1991; Smorodin, 1984; Pratt, 1980).

A related question is whether or not the presence of laboratory assistants is associated with the amount of student laboratory activity. However, if this is the case, one would expect to see a rural-urban difference in laboratory activity corresponding to the lack of assistants in the rural sub-sample. Since there is no rural-urban difference in the amount of student laboratory activity, it is possible that assistants make no difference in an area where the regular classroom teacher already possesses both sufficient knowledge and experience. Again, this would be a vindication of placing great importance on the background knowledge of the teacher in realizing the implementation of any particular aspect of curriculum and, in this case, upon the background knowledge of the assistant in aiding the teacher in the implementation of new regulations.

While the statistical evidence for the importance of availability of laboratory assistants is convincing, other factors, such as grade level taught,may provide a significant association while not themselves being associated significantly with the availability of laboratory assistants.

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Selected Teacher and School Characteristics For Rural and Urban Locations and For Schools of Various Size Student Populations

Teacher Characteristics

Rural and urban teachers are remarkably similar except in 2 areas: 1) the degree to which their teaching experience matches the grades and subjects they currently are assigned to teach, and 2) the amount of professional training they have in science methods and curriculum. Urban teachers are concentrated in higher WHMIS categories for both of these areas. No significant difference occurs either in the proportion of teachers assigned various grades (grades 11-12, in particular) or in the amount of university science credit hours obtained. This latter fact is an interesting contradiction to the research of Carlsen and Monk (1992) which indicates that the average rural American science teacher has taken fewer science courses than their urban counterparts.

Degree of Matching of Teaching Experience with Current Teaching Assignments

The finding that rural teachers are less likely to have extensive experience in teaching the subjects and grades of their current assignment is, however, in agreement with Carlsen and Monk (1992), who report that rural science teachers are more likely to have taught subjects other than science. Guay's (1980) Southern Alberta study of rural-urban differences also concludes that rural teachers are less likely to have specialized teaching assignments, and that junior high science teachers especially might be expected to teach any subject offered at the school.

Possible reasons for the rural-urban difference in the association between teaching experience and current assignments might be that there are more transfers, or more first and second year teachers in rural locations. In this sample, however, there is no significant difference between rural and urban teachers in either total years of experience or in the number of years spent at their current school.

There was no significant association between the degree of experience in the current teaching area and the size of the student population. Therefore the rural-urban difference in experience in current teaching assignments does not appear to be associated with the small size of some rural schools. This leaves the possibility of increased movement of teachers among subject areas and grades within rural schools. Such movement within rural schools could occur for some individuals who currently are teaching science, but missed out on WHMIS inservices or information sessions as a result of teaching subjects other than science at the time the information was given.

Amount of Professional Training in Science Methods and Curriculum

Although one might interpret the lower amount of professional training in science teaching for rural teachers as a trend toward rural hiring of teachers who have not been prepared to teach science, such is not the case. There is no significant difference between rural and urban teachers in the degree to which their university science training matches their grade and subject assignments.

Furthermore, the difference does not suggest an actual deficiency in professional training among rural science teachers, as 70 percent, the same percentage as the urban teachers, have obtained some credits in science methods or curriculum. The difference results from urban teachers having obtained more than the usual 6 credit hours. Sixty-one percent of urban compared to only 45 percent of rural teachers obtained more than 6 credit hours of professional preparation applicable to science. Carlsen and Monk (1992) also report that rural science teachers in the United States, where teachers are subject-certified, have taken fewer science methods courses than had urban teachers. The difference noted in that study, as well as in this Manitoba

study, might indicate a more easily accessible source of post-graduate courses and professional development opportunities for urban teachers.

School Characteristics

Size Student Population

All of the very small schools involved in this study are in rural locations. However, even when schools with fewer than 200 students are removed from consideration, there still a statistically significant difference in school sizes, with a higher percentage of urban schools having higher student populations.

Access to Laboratory Assistants

The availability of laboratory assistants is almost exclusively a characteristic of urban schools. In addition, the larger the student population, the more frequent the hiring of laboratory assistants. The data show a slight tendency for grade 11-12 teachers to be more likely to have assistants, although there is no statistical significance for the numbers involved. The three rural teachers reporting assistants are grade 11-12 teachers. However, these three account for only 6 percent of the total number of rural grade 11-12 teachers. Within the urban sub-sample there is no statistically significant difference in grades taught and access to an assistant, although 49 percent of urban grade 11-12 teachers report access to an assistant. This did create a significant difference in the availability of assistants for rural as compared to urban grade 11-12 teachers. As there is no difference in the proportion of rural compared to urban teachers assigned grades 11-12, the lack of laboratory assistants for the rural teachers may account for much of the difference in WHMIS categories between rural and urban teachers.

Rural-Urban Profiles

There are more differences between rural and urban schools in terms of school-related characteristics than there are in terms of teacher-related characteristics.

Teacher Characteristics

Rural and urban science teachers are similar in all characteristics except the degree to which their experience matches their current teaching assignment and the amount of professional preparation in excess of 6 credit hours. Urban teachers are in a better position in these two areas only. As both of these characteristics are associated with WHMIS categories, the difference may provide part of the explanation for improved urban knowledge and implementation of WHMIS regulations.

School Characteristics

There are significant rural-urban differences in all three of the school characteristics surveyed. The size of the student population and the availability of laboratory assistants have been discussed because they are significantly associated with WHMIS knowledge and implementation. In addition, rural and urban schools differ in average class size, with rural teachers having smaller average class sizes. According to Colton (1991), this is one of the strengths of rural schools. There also is a significant difference in average class size among schools of different size student populations, with teachers at smaller schools reporting smaller numbers of students per class. This difference persists when schools of less than 100 students are removed from consideration, indicating that the pattern exists throughout the rural sub-sample and is not confined to the smallest schools. The smaller student-teacher ratio, however, does not provide the teacher with more

time for learning about and implementing new material, such as the WHMIS regulations. Neither is it a negative factor as the variable of class size is not associated with WHMIS implementation. It is possible that increases in time provided by smaller classes are offset by more classes and more subjects to be prepared.

Associations Between WHMIS Knowledge and Implementation and the Amount of Student Laboratory Activity

The level of student laboratory activity was measured by an estimate by the teacher of the amount of time spent on such activities, and is somewhat subjective. Because it is used for comparative rather than absolute purposes, problems introduced by the subjectivity of the measure are expected to be common to all the groups being compared and would not figure significantly in the outcomes. The measurement of student laboratory activity as a proportion of the provincially-recommended number for grade 11 and 12 sciences requires an actual count of activities done and is less of a problem subjectivity.

Significant differences in the association between WHMIS knowledge and implementation and student laboratory activity occur only where teachers report making actual changes to their student laboratory activities as a result of implementing WHMIS regulations. The reporting of WHMIS-related lab changes is associated with an overall decrease in the amount of student laboratory activity. Such decreases, however, are not themselves linked to WHMIS categories.

Nor were significant differences found between WHMIS categories and the total amount of laboratory activity, measured either as an estimate of the percentage time spent on these activities or as a proportion of the recommended number of grade 11-12 student laboratory activities. Teachers who are more involved in student laboratory activity are no better or worse implementers of WHMIS regulations than are those with less involvement. Conversely, teachers who obtain high WHMIS scores are no more likely than those with low scores to spend any given amount of time on laboratory activities. All of these results suggest that only those aspects of WHMIS implementation that result in specific changes to laboratory activities, and not WHMIS implementation in general, are associated with decreases in laboratory activity.

Associations Between WHMIS Categories and Reported WHMIS-Related Changes in Laboratory Activities

Teachers reporting no WHMIS-related changes have significantly lower scores for WHMIS knowledge and implementation. It is possible that lack of knowledge implies that they are unaware of the necessity for changes in their labs or classrooms. It also could indicate that teachers with reports of no WHMIS-related changes may not be doing experimental work of the type that requires change in order to comply with WHMIS regulations.

Associations Between Decreases in Student Laboratory Activity and Changes to Student Laboratory Activity as a Result of Implementation of WHMIS Regulations

Teachers who made WHMIS-related changes are more likely to have experienced an overall decrease in student laboratory activity over the past 5 years than are teachers who report not having made WHMIS-related changes. The lack of association between amount of laboratory activity and WHMIS scores is countered somewhat by the WHMIS-change/decreasing lab result and further study definitely is called for before the effect of WHMIS on the amount of student laboratory activity can be determined. Faulkner (1993), Beach and Stone (1988), and Everett and DeLoach (1988) may be justifiably concerned about the effects of the implementation of new and involved safety regulations upon student laboratory activity.

Differences in the Amount of Student Laboratory Activity for Rural-Urban Locations and for Schools of Different Size Student Populations

Changes to Student Laboratory Activities as a Result of WHMIS Regulations

A slightly higher percentage of urban teachers make WHMIS-related changes. The difference between rural and urban teachers, however, is not statistically significant. Therefore, the association between WHMIS categories and WHMIS-related laboratory changes does not help explain the rural-urban difference in WHMIS knowledge and implementation.

About one-tenth of both rural and urban teachers believe that such changes are detrimental to student learning. As a result, it is tempting to suggest that WHMIS has not been detrimental to the quantity of student laboratory work being done in Manitoba. On the other hand, the small number of teachers complaining about the effect of WHMIS-related changes is associated significantly with higher WHMIS categories. As there are few implementing at the higher levels, the subsample of teachers in this position is too small to draw that conclusion.

Rural-Urban Profiles for Amount of Student Laboratory Activity

Estimated Percentage of Classroom Time Devoted to Student Laboratory Activities: Rural-Urban Comparisons

The significant difference in laboratory activity between rural and urban teachers appears to have been created by the rural teachers in student lab category 3 and 4. While this number is too small for a separate statistical comparison with the rest of the sample, these teachers are deleted from consideration and only categories 0, 1 and 2 are compared. There is no significant rural-urban differences among these remaining teachers, who constitute 96 percent of the sample.

The complete absence of any urban teachers from percentage-time category 3 and 4 may indicate either an actual upper limit on student laboratory activity on the part of urban teachers, or more conservative time estimates on the part of urban teachers.

Estimated Percentage Time Devoted to Student Laboratory Activities: School Student Population Differences

The size of the student population at a teacher's school is not a statistically significant variable in the analysis of the estimated percentage of classroom time spent on student laboratory activity.

Number of Student Laboratory Activities as a Percentage of Those Recommended by Grades 11-12 Curriculum Guides: Rural -Urban Comparisons and School Student Population Comparisons

The number of student labs reported by grade 11-12 teachers is compared to the number of laboratory activities recommended by Provincial curriculum guides for the subjects taught. In terms of the resulting laboratory categories, there is no significant difference either between rural and urban teachers or among teachers at schools of various student populations. No grade 11-12 teachers report zero student laboratory activity, and high numbers of both rural and urban teachers implement the recommended or more than the

recommended number of student laboratory activities. If the provincial guides are accepted as a standard, Manitoba students generally are exposed to a sufficient amount of laboratory work.

In summary, rural Manitoba science teachers are spending as much time on student laboratory activities as are urban teachers. At the grade 11-12 level, the majority of both rural and urban students are exposed to the amount of laboratory activities recommended by provincial curriculum guides. Students attending rural schools are not at a disadvantage in terms of the amount of laboratory activity included in their science curriculum.

CONCLUSIONS, LIMITATIONS OF THE RESEARCH AND SUGGESTIONS FOR FURTHER STUDY

A number of general conclusions are drawn from the results of this study. However, analysis of the data raises a number of new questions that can be answered only through further research.

This summary begins by reviewing the statistically significant associations between the variables of the study. This is followed by conclusions, and the limitations and recommendations for further research for each section of the report. The final component is a brief list of answers to the more important questions asked in this research and some recommendations for action based upon the results.

The following variables have statistically significant positive associations with WHMIS knowledge and implementation:

1. Reports of accidents involving injury to students,
2. Occurrence of laboratory or classroom inspection for implementation of WHMIS regulations,
3. Urban school location for responding teachers,
4. School student population of more than 100,
5. Increased teacher experience in subjects and grades of the current teaching assignment,
6. Assignment of grades 11-12,
7. A higher number of credit hours in university science courses,
8. A higher number of credit hours in courses in science methods and curriculum,
9. Access to full-time or part-time laboratory assistants, and
10. Reports of WHMIS-related changes to laboratory activities

The following variables have statistically significant associations with rural locations:

1. Lower WHMIS category scores,
2. Smaller school student population,
3. Teachers less experienced in subjects and grades of current teaching assignments,
4. Fewer credit hours in science methods and curriculum,
5. Smaller average class size,
6. Infrequent access to full-time or part-time laboratory assistants, and
7. Fewer reports of overall decreases in student laboratory activities.

An initial limitation of this study is that common to all questionnaire research. Subjects assess their own behaviours and there is always the possibility of a discrepancy between what the subject perceives to be the answer and what an outside observer might perceive to be the answer. While an attempt was made to make items of the questionnaire specific, it was not possible to completely eliminate this source of error. Nor was there any opportunity to corroborate results by non-questionnaire means, such as direct observation or document research. A major recommendation of this study is that the variables be studied further, using a variety of methods.

Another obvious limitation of this research was the attempt to survey a large number of variables. The lack of replicated research in the area of science laboratory curriculum implementation does not permit identification of a few specific variables as being especially relevant. Thus, in order to limit the size of the questionnaire and insure a response rate large enough to permit statistical analysis, no single variable could be studied in great detail.

Degree of Knowledge and Implementation of WHMIS

Knowledge and implementation of the WHMIS regulations are low. This implies that inservice education regarding the regulations and their classroom implementation has not been successful. Implementation of safety factors that overlap earlier practice is, however, much higher. This latter fact, combined with a lack of serious accidents and with the teachers' lack of conviction that implementation of WHMIS regulations would have prevented the occurrence of any accidents that have been reported, leads to the conclusion that some of the lack of implementation might be attributed to lack of motivation for change.

Reluctance to implement, however, appears to be overcome if an inspection of the teacher's laboratory and/or classroom is made. This suggests that outside pressure is effective, to some extent, in insuring that the regulations are implemented.

Limitations of this Aspect of the Study and Suggestions for Further Study

As a result of the lack of previous research that could identify the important variables to be measured, the questionnaire was designed to measure only those variables that the researcher believed to be relevant. Analysis indicates that not all of the measured variables are relevant and there may be other important variables that are not measured. The actual amount and type of inservice training teachers have before they are expected to implement the WHMIS regulations should be measured. This would aid in confirming or casting doubt upon the study by Slaugh (1984), which suggests that inservice work beyond what is normally

thought adequate is necessary if implementation is to take place. A collection of the dates of WHMIS inservices or information sessions would be useful in establishing whether or not such sessions were limited to the years immediately before and following the regulations becoming law, or whether ongoing training is available.

In order to determine whether teacher motivation is a factor, it would be useful to include a direct question on whether or not the teacher believes implementation of WHMIS regulations is necessary for student laboratory safety. Data were collected on whether or not teachers who had reported student injuries believed that implementation of WHMIS regulations would have prevented the accident. Unfortunately, this item is limited to teachers reporting accidents. Because these teachers are a minority, the opinion of most of the respondents regarding the necessity of WHMIS implementation is excluded.

Further questioning of teachers on whether or not they believe WHMIS legislation should be modified in the case of school laboratories, and on reasons for their answers, also would add to knowledge regarding their motivation for implementation or lack thereof. If a lack of motivation to implement is associated with a lack of need for further regulations in classroom/laboratory situations, then the relationship between theory and practice, as advocated by Connelley and Clandinin (1988), would lead to further investigation into the feasibility of a modification of the legislation as it applies to schools.

WHMIS and General Safety Knowledge and Implementation: Rural-Urban and School Size Comparisons

Significant differences between rural and urban teachers exist only in the implementation of those aspects of WHMIS that require actual changes in classroom practice. Urban teachers are concentrated in higher WHMIS knowledge and implementation categories.

The rural-urban difference in WHMIS knowledge and implementation is not matched by any significant rural-urban differences in awareness that WHMIS exists, in the frequency of reported accidents, or in the frequency of WHMIS inspection.

Teachers working at schools with a small student population, especially those with less than 100 students, have a significantly higher probability of being in a low WHMIS category than do teachers at larger schools. Because all schools serving fewer than 100 students are located in rural areas, this is important for explaining the rural-urban difference in implementation. Tests on sub-samples, however, indicate that this is not the only source of the rural-urban implementation difference.

The most significant limitation of this portion of the research is sample size. When the full sample is broken into sub-groups, the problem of low expected frequencies interferes with a detailed statistical study. While it is tempting to isolate teachers in groups that provide reasons for the significant differences between larger groups, results would not be statistically valid. As a result, further studies of larger samples, or studies concentrating on larger samples from particular sub-groups such as non-implementers, or teachers at schools of less than 100 students, would be useful in expanding the results of this research.

Relationships Between WHMIS Categories and Selected Teacher and School Characteristics

Teacher characteristics that are associated with their WHMIS categorization are 1) the amount of experience teaching the grades and subjects currently assigned, 2) the grades taught, 3) the number of university science courses taken, and 4) the number of professional courses taken. All of these are possible sources of teacher facility in lesson preparation and delivery, thus giving the teacher more time to devote to

acquiring and implementing new material such as WHMIS. These variables also may be a source of attitude development congenial to implementation. As suggested previously, the amount of experience in the subjects and grades currently assigned might relate to whether or not inservice training was received.

The most important school characteristic associated with teacher implementation of WHMIS is access to laboratory assistants. It is assumed that access to assistants is helpful in providing additional time for teachers as well as providing the collegiality which other studies cite as useful to implementation (Brosnan, 1994; Rafferty, 1992; Fullan, 1991; Smorodin, 1984; James and Hall, 1981).

The result regarding a teacher's experience in a current teaching assignment differs from other implementation studies. For example, McLaughlin and Marsh (1978) indicate that more extensive experience is an inhibiting factor. Further study into when inservice training in WHMIS was given and whether it was recently discontinued could provide an explanation for this difference.

In consideration of the significance to implementation of the presence of laboratory assistants, a more detailed study of characteristics and the possible role of assistants would be valuable. The following questions provide topics for further research.

1) Does the presence of an assistant create more available time in which knowledge of WHMIS regulations could be obtained and implemented by the classroom teacher? An observation of the actual tasks done by an assistant and the difference this makes to the classroom teacher in terms of available minutes and hours on a daily basis could be undertaken.

2) Does an assistant provide a readily available source of information about the WHMIS regulations and thus act in the capacity of an ongoing inservice for the classroom teacher? A survey of laboratory assistants to assess their knowledge and implementation of the WHMIS regulations would be useful in attempting to assess this possibility.

3) Does working in proximity to the knowledge and skills of a laboratory assistant produce more confidence and motivation on the part of the assisted teacher to learn and implement the material? A study of the academic and professional background of laboratory assistants would aid in determining to what extent the assistant's influence is felt as the voice of practical experience, validating the material and techniques being implemented.

As the significance of the association of laboratory assistants with WHMIS categories appears to be in agreement with similar studies reporting the importance of personal contact to other areas of implementation, it would be worthwhile to explore the role of the assistant through classroom observation, surveys, and records of their background.

Selected Teacher and School Characteristics: Rural-Urban and School Size Comparisons

Rural teachers have less experience teaching the specific subjects and grades they currently are assigned, and have fewer credit hours of professional training in science methods and curriculum than do urban teachers. Beyond these two characteristics, rural and urban teachers display similar profiles. This rural-urban similarity also is noted by Carlsen and Monk (1992).

It was rare for teachers at rural schools to have access to the services of a laboratory assistant. In contrast, over one-third of the urban teachers have access to an assistant. The probability of an urban teacher having an assistant increases with an increase in the student population. Because access to an assistant is an important factor in terms of WHMIS knowledge and implementation, the lack of assistants for rural teachers may

explain a portion of the rural-urban difference in implementation. Differences are not explained entirely by the presence of small rural schools.

The fact that teachers at rural schools have smaller classes is not statistically significant in terms of WHMIS knowledge and implementation.

The possibility of increased movement of teachers between subject areas and grades within rural schools is an interesting area for further study. Carlsen and Monk (1992) and Guay (1980) confirm reduced experience of rural science teachers in their current teaching assignments. The dates when WHMIS material was presented to teachers are needed to assess whether movement of teachers among subject areas could have caused some to miss this training.

The nature of the association between the additional professional courses taken by urban teachers and their higher WHMIS scores might be clarified if a survey is made of whether or not the WHMIS regulations have been a topic of those courses.

The importance of access to laboratory assistants suggests that a study into finding the ways and means of providing rural teachers with assistants, or the services of someone who could supply similar services, even on a rotating basis such as suggested by Colton (1981), might be useful in improving rural implementation levels. A study of the role of existing science consultants in supplying rural teachers with information about WHMIS also would indicate whether or not this is a strategy that has been tried.

The fact that average class size, which is smaller in rural schools, neither aided nor hindered the teacher's efforts at implementation of WHMIS regulations suggests that either a small size class does not make a difference in the time spent in preparation, or any savings in time is offset by a possibility that the teacher has a larger number of different subjects to prepare. Since Colton (1981) argues that small class size results in superior education, this is another topic that might be investigated in an examination of the strengths and weaknesses of small rural schools.

Associations Between the Amount of Student Laboratory Activity and WHMIS Knowledge and Implementation

No significant associations are apparent either between the estimated percentage time spent on student labs or, in the case of grade 11-12 teachers, between the percentage of the number of labs recommended in provincial curriculum guides and the number completed and a teacher's knowledge and implementation of WHMIS regulations. These results suggest that concern about increased implementation of safety regulations having an adverse affect upon student laboratory activities is unfounded.

This conclusion, however, must be modified by the significant association between higher WHMIS scores and a higher number of teachers reporting WHMIS-related deletions or changes to their laboratory work. A conclusion of no effect of WHMIS implementation on laboratory work is further weakened by the significant positive association between teachers' reports of specific WHMIS-related changes and teachers' reports of decreases over the past 5 years in the overall amount of student laboratory activity. When moving from a general discussion of student laboratory activity to specific types of activities, it appears that relationships with the implementation of WHMIS regulations become more important and contradict the findings indicating no relationship with the amount of laboratory activity.

The measure of amount of student activity as a percentage of classroom time is subjective. Studies consisting of laboratory/classroom observations and of examinations of lesson plans and student laboratory report books could indicate whether the self-reports are valid. The measure of the number of grade 11-12 student laboratory activities compared to the number recommended is less subjective in that it involves a

count of activities done. Because it also has no association with the amount of WHMIS knowledge/implementation, it is possible that an improved measure of percentage time would not yield substantially different results. Without further research, however, this remains a matter of conjecture.

Furthermore, the measure provides no information regarding the types of student laboratory activities occurring. Nor are there large enough subsamples of teachers of separate subjects to permit a comparison of implementation between teachers of different subjects. Future studies should measure the type of laboratory activities as well as the number of activities when investigating possible effects of WHMIS implementation. Therefore, researchers studying this area might concentrate on teachers of specific subjects or specific aspects of student laboratory activity, such as changes in the number of experiments actually involving the WHMIS regulations.

Obtaining a larger sample of teachers who are actively involved in WHMIS implementation, and studying the specific types of laboratory activities which occur in their classes could provide an explanation of the association between decreases in the amount of student laboratory activity, WHMIS-related laboratory changes and the teacher's degree of knowledge and implementation of the WHMIS regulations.

Rural-Urban Differences in Student Laboratory Activity

While a significant association occurs between rural-urban location and percentage of time spent on student laboratory activity, further investigation shows the result to be ascribed primarily to eight rural teachers who report in excess of 50 percent of their classroom time spent on student laboratory activity. When this fact is combined with the subjectivity of the measure, the ability to interpret the importance of the result decreases.

When the amount of laboratory activity is measured by a count of the grade 11 and 12 activities done compared to the recommended number, there is no longer a significant difference between rural and urban teachers.

These conflicting results again point up the weakness of the subjective measure of the percentage time spent on student laboratory activity. The complete absence of urban teachers from percentage-time category 3 and 4 may indicate either an actual upper limit on student laboratory activity on the part of urban teachers or merely a trend to more conservative time estimates on the part of urban teachers. The previously-mentioned subjectivity of the estimate might be a factor and suggests that a study of the association of location to perception of time spent might be a useful area of further research. It also is possible that rural reports of a higher percentage of time spent on student laboratory activities are correct and are an indication of rural schools offering quality education.

Rural-Urban Profiles

Science teachers at rural schools are similar to those at urban schools in terms of preparation for teaching science. They do not differ significantly in the number of credit hours of university science courses taken and, even though urban teachers have taken more professional training, rural teachers are not without such training. Rural schools differ significantly from urban schools in only a few teacher characteristics but these are all associated significantly to WHMIS knowledge and implementation. The most significant difference, both in relation to WHMIS knowledge and implementation and in relation to rural-urban and school size variation is access to either a full-time or part-time laboratory assistant.

There is little difference between rural and urban schools in terms of the amount of student laboratory activities or in the effects of WHMIS regulations on those activities as perceived by teachers. Urban teachers

report decreases in student laboratory activity more frequently than do rural teachers, while more rural teachers report large amounts of time spent on student laboratory activities.

The most important difference is the tendency for urban teachers to be at an advantage in terms of knowledge and implementation of WHMIS regulations.

SUMMARY AND RECOMMENDATIONS

This research provides answers to the questions posed in the introduction.

1) Were Manitoba junior and senior high school teachers aware of the existence of the WHMIS regulations? Yes, nearly 90 percent are aware of them.
2) Are the teachers knowledgable about details of the regulations and are they implementing them in their classrooms and/or laboratories? Some are but the overall level of knowledge and implementation is low.
3) Are there many instances of student injuries during laboratory activities? No.
4) Is the occurrence of a laboratory/classroom inspection related to scores that place teachers in higher WHMIS categories? Yes.
5) Are there differences in knowledge and implementation between rural and urban teachers? Yes. Urban teachers appear to be at an advantage regarding knowledge and implementation.
6) Are there differences in knowledge and implementation among teachers working at schools with different size student populations? Yes. WHMIS knowledge and implementation is lower in smaller schools.
7) Is there a difference in location of smaller schools? Yes. They all are in rural locations.
8) Are there any teacher characteristics that are associated with higher levels of knowledge and implementation? Yes. The degree to which past teaching experience matches the current teaching assignment, the grades taught, the number of credit hours in university science courses and the number of credit hours of professional courses in science methods and/or curriculum studies all are significantly, and positively associated with a teacher's WHMIS category.
9) Are there any school characteristics, other than size and location, that are associated with higher levels of WHMIS knowledge and implementation? Yes. Teachers at schools that provide access to a part-time or full-time laboratory assistant have significantly higher WHMIS scores.
10) Are any of the above variables that are significantly associated with WHMIS categories, also related to school location? Yes. Teachers at schools in urban locations have more experience in their current teaching area, more credit hours of professional courses and greater access to laboratory assistants.
11) Is there any association between the degree of WHMIS knowledge and implementation and the amount of student laboratory activity? There is no association between WHMIS categories and either of the two measures of the amount of student laboratory activity. Higher WHMIS categories, however, are accompanied significantly more frequently by teachers reporting specific changes to their laboratory activity as a result of WHMIS implementation. Teachers reporting WHMIS-related changes to their laboratory activity also are significantly more likely to have reported an overall decrease in student laboratory activity.
12) Are there any important rural-urban differences in the amount of student laboratory activity? No.

Recommendations

The final recommendations fall into 2 categories: 1) recommendations to facilitate and improve WHMIS knowledge and implementation, and 2) recommendations for future research to determine whether full implementation is necessary for student safety, and desirable from the standpoint of maintaining student laboratory activity. If not, should the regulations be modified for school laboratories?

Improving WHMIS Knowledge/Implementation

Results suggest that teachers might not perceive a practical need for adding WHMIS regulations to their laboratory activities. As a result, they are unlikely to seek more information about the implementation of the regulations unless they are made aware of the facts that the regulations are law and there are penalties associated with non-compliance. The research also suggests that it is possible that many teachers, especially in rural locations, may have missed earlier information sessions and inservices and may lack easy access to professional development courses that offer the information. A provincially-sponsored program designed to inform teachers of these circumstances and to re-acquaint teachers whose earlier training is incomplete would be a reasonable first step toward improved implementation. The variables of professional background and related teaching experience can not be changed quickly, although they may well be considered in discussions of teacher training curricula and school division placement policies.

The role of laboratory assistants in aiding urban teachers to obtain better WHMIS knowledge and implementation deserves further investigation, especially in regard to whether a similar effect might be achieved for rural teachers through shared assistants, or an extension of the role of science curriculum coordinators. It appears that the physical presence of an individual who is knowledgeable about WHMIS implementation would be most likely to bring more immediate improved results. The recent literature, as well as the results of this research, suggest that this would be an effort that would yield returns.

Increased inspections and the dissemination of information that such inspections could be expected at any time also might increase the motivation for teachers to become better implementers.

Further Research into the Desirability of Increased Implementation

Whether or not the above recommendations are worth the time and cost of implementation depends on the answers to the questions of how increased implementation of the WHMIS regulations might affect student learning and safety, and whether there is a rational basis for arguing for a modification of WHMIS regulations as applied to school laboratories. Modern approaches to curriculum implementation suggest that the very fact that implementation of a curriculum innovation is not occurring should cause those concerned to re-evaluate the need for and usefulness of the innovation before proceeding with further intervention. This research establishes that there is little in the way of laboratory accidents or lack of "general safety" measures that would provide motivation for teachers to seek further safety measures. In addition, the contradictory results regarding the effect of WHMIS implementation on student laboratory activity suggest that concerns regarding the difficulty of full implementation of both have not been disproved. Therefore, while the recommendations to improve WHMIS implementation might be made, it is necessary to add the cautioning note that if the regulations are not meeting an actual classroom need, the expense of implementation could prove too costly either in terms of resources or in terms of lost student laboratory activities. On the other hand, Government agencies in charge of WHMIS regulations might not be convinced that modifications making the regulations more easily implemented in the school setting would be a reasonable alternative to the current situation. In this case, there will be no choice but to improve WHMIS knowledge and implementation or face legal penalties. Aspects of suggested further research that could provide arguments for the modification of the regulations include the following:

1) more objective measures of student laboratory activity and more subject and activity specific studies that would facilitate further studies into the effect of WHMIS implementation upon student laboratory activity,
2) further studies into the desirability of student laboratory activity, and
3) an investigation into legal precedents that would enhance the possibility of modifying the WHMIS regulations for schools.

As long as the implementation of WHMIS regulations is mandated for school science teachers, it will be necessary to take the traditional view of curriculum implementation and try to find and use any interventions that will bring the goal of complete implementation closer. The other possibility is that a demonstration that science teachers are maintaining a reasonable level of safety for their students, and attempts to improve implementation of WHMIS regulations as they now apply to schools would be resource-costly as well as endangering the implementation of student laboratory activity would result in an effort to modify the regulations in the case of school laboratories. In that case we would be experiencing an instance of the more recent, dialectical view of curriculum implementation.

REFERENCES

Beach, D.H. & Stone, H.M. (1988). Survival of the high school chemistry lab. Journal of Chemical Education, 65(7), 619-620.

Blossor, P.E. (1983). The role of the laboratory in science teaching. School Science and Mathematics, 83(2), 165-169.

Brosnan, P.A., Edwards, T. & Erikson, D. (1994). An exploration of change in teacher's beliefs and practices during implementation of mathematics standards. Columbus, OH. Ohio State University.

Carlsen, W.S. & Monk, D.H. (1992). Rural\nonrural differences among secondary science teachers: Evidence from the longitudinal study of American youth. Paper presented at the annual meeting of the American Educational Research Association, San Francisco, CA.

Colton, R.W. (1981). The science program in small rural secondary schools. Paper published by Clearinghouse on Rural Education and Small Schools, Las Cruces, N.M.

Connelly, F.M. & Clandinin, D.J. (1988). Teachers as curriculum planners: Narratives of experience. Toronto, ON: OISE Press

Edington, E.D. (1983). Science and mathematics teachers' needs in the rural schools. Written testimony for United States Budget Committee hearing held at Las Cruces, N.M.

Everett, K.G. & DeLoach, W.S. (1988). What fate for laboratory safety courses? Journal of Chemical Education, 65(7), A177-A179.

Faulkner, S.P. (1993). Lessons with a fizz: Speedy relief for teaching chemistry concepts. The Science Teacher. January,1993, 27-19.

Feldman, A. & Atkin, J.M. (1993). Research in science education in the USA. Journal of Curriculum Studies, 25(3), 281-289.

Fullan, M.G. & Stiegelbauer, S. (1991). The new meaning of educational change. (2nd ed.). New York: Teacher's College Press.

Gass, J.R. (1990). Chemistry, courtrooms, and common sense. Journal of Chemical Education, 67(1), 51-55.

Gerlovich, J.A. (1992). OSHA's new chemical lab standard and its impact on school science laboratories. Journal of Chemical Education, 69(8), 643-644.

Guay, J. (1980). Biology and lifescience classroom teaching environment in Southern Alberta. AB: University of Lethbridge.

James, R.K. & Hall, G. (1981). A study of the concerns of science teachers regarding an implementation of ISCS. Journal of Research in Science Teaching, 18(6), 479-487.

Manitoba Environment and Workplace Safety and Health. (1988). A workplace guidance manual to the Hazardous Materials Information System (WHMIS): Manitoba regulation 52/88. Winnipeg.

Manitoba Government document. (1988). The workplace safety and health act: Being chapter W210 of the continuing consolidation of the statutes of Manitoba. Winnipeg: Queen's Printer for the Province of Manitoba.

Manitoba Government document. (1989). Manitoba regulation 52/88: Workplace Hazardous Materials Information System regulation and Manitoba regulation 53/88: Workplace Health Hazard regulation: Being regulations under the workplace safety and health act: Office consolidation. Winnipeg: Queen's Printer for the Province of Manitoba.

Manitoba Labour Workplace Safety and Health Branch. (1990). Program No. 4: Introduction to the workplace hazardous materials information system (WHMIS). Winnipeg.

McLaughlin, M.W. & Marsh, D.D. (1978). Staff development and school change. Teachers College Record, 80(1), 69-94.

Meadows, T. (1991). What's "Wimmis"? The Manitoba Science Teacher. February, 1991, 4-7.

Minister of Supply and Services Canada. (1992). WHMIS in your workplace. Ottawa.

Minister of Supply and Services Canada.(1993). WHMIS education and training programs: Guidelines for employers, workers and regulatory agencies. Ottawa.

Olstad, R.G. & Haury, D.L. (1984). A summary of research in science education -1982. Science Education, 68(3), 207-363.

Pratt, D. (1980). Curriculum: Design and development. New York: Harcourt, Brace, Jovanovich, Inc.

Rafferty, C.D. (1992). What will it take to ensure implementation? A content literacy dilemma. Paper presented at the annual meeting of the National Reading Conference, San Antonio, TX.

Shulman, L.S. & Tamir, P. (1973). Research on teaching in the natural sciences. In R.M.W. Travers (Ed.) Second handbook of research on teaching. (pp. 1099-1148). Chicago: Rand McNally.

Siegel, S. (1956). Non-parametric statistics for the behavioral sciences. New York: McGraw-Hill Book Company.

Slaugh, L.A.C. (1984). Perceived barriers to implementing Florida's competency-based business education curriculum. Paper presented at the American Vocational Association Convention, New Orleans, LA.

Smorodin, C. (1984). Why teachers implement: An examination of selected variables. Paper presented at the annual meeting of the American Educational Research Association, New Orleans, LA.

Toch, T. (1991). The struggle to reform and why its failing. The School Administrator. February, 1991, 16-18.

W.H.M.I.S.: Training manual. (undated). Manitoba Association of School Trustees. Risk Management Department.

White, R.T. & Tisher, R.P. (1986). Research on natural sciences. In M.C. Wittrock (Ed.), Handbook of research on teaching (3rd.ed.) (pp. 874-905). New York: Macmillan.

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* Rounds, R.C., editor. 1993. *Restructuring Industrial Production and Tradeable Services in Rural Canada in the 1990's, Brandon, Manitoba 2-5 July, 1992*. ARRG Working Paper Series, Number 3, The Rural Development Institute, Brandon University, Brandon, MB, 71 pp. ($12.20).

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